APPENDIX D

South San Francisco Bay Shoreline With Project Economics Appendix

SOUTH SAN FRANCISCO BAY SHORELINE

INTERIM FEASIBILITY STUDY

ALVISO PONDS AND SANTA CLARA COUNTY, CA

Economics Appendix

(Appendix D to Draft Feasibility Report/EIS)

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Executive Summary

Purpose & Methods

This report describes the evaluation and comparison of the economic justification and cost effectiveness of various measures to reduce flood risk and provide ecosystem restoration in the study area.

The flood risk management options are first evaluated separately from the ecosystem restoration measures in order to determine the single-purpose flood risk management National Economic Development (NED) option. The NED flood risk management option[1] produces the greatest net national economic benefits measured in dollars. The HEC-FDA computer program was used to estimate future without-project expected flood damage and to estimate the damages reduced and residual damage associated with various project options intended to reduce flood risk in the area. Statistical results of the HEC-FDA program were used to describe existing and future without-project and with-project likelihood of coastal flooding. The HEC-FDA model is a planning model that has been certified for use in U.S. Army USACE of Engineers (USACE) feasibility studies.

The ecosystem restoration measures are evaluated and compared separately from the flood risk measures using two methods – cost-effectiveness (CE) analysis and incremental cost analysis (ICA), jointly called CE/ICA. The CE/ICA was conducted using the Institute for Water Resources (IWR) Plan computer program, which is certified for use in USACE feasibility studies. The National Ecosystem Restoration (NER) option is to be selected from the subset of cost-effective options.

Ultimately, the USACE planning process results in the identification of an alternative that is known as the NED/NER Alternative. The USACE Planning Guidance Notebook describes alternative recommendation for multi-purpose projects as follows:

Projects which produce both National Economic Development (NED) benefits and National Ecosystem Restoration (NER) benefits will result in a "best" recommended plan so that no alternative plan or scale has a higher excess of NED benefits plus NER benefits over total project costs. This plan shall attempt to maximize the sum of net NED and NER benefits, and to offer the best balance between two Federal objectives. Recommendations for multipurpose projects will be based on a combination of NED benefit-cost analysis, and NER benefits analysis, including cost effectiveness and incremental cost analysis.

The primary sources of policy and procedural guidance for this analysis are the following: *Planning Guidance Notebook* – ER 1105-2-100; *Evaluation of Environmental Investments Procedures Manual* – IWR Report 95-R-1*; Incorporating Sea Level Considerations in Civil Works Programs* – ER 1100-2-8162.

[1] This report uses the term "option" for the single-purpose flood risk management (FRM) and ecosystem restoration (ER) plans, and reserves the term "alternative" for the combined, multi-purpose FRM and ER plans, including the NED/NER plan.

Existing & Future Without-Project Flood Risk

There are approximately 2,100 people living in the floodplain, mostly low-income minority families. There are estimated to be another 3,000 individuals that work in the area and are considered part of the overall "population at risk" (PAR).

Characterizing the flood risk to this and any other community involves the qualitative or quantitative description of the nature, magnitude and likelihood of the adverse effects associated with the flood hazard. The purpose of characterizing the flood risk is to support decisions related to reducing the risk to people and property in the floodplain. Characterizing the flood risk requires answering four important questions:

1. What can go wrong?
2. How can it happen?
3. What are the consequences?
4. How likely is it to happen?

The goal of the flood risk analysis component of the South San Francisco Bay Shoreline Feasibility Study is to answer these four questions in sufficient detail to support decisions that may reduce the flood risk in the study area. The study is focused on reducing the risk of tidal flooding, which could happen if water from the bay overtops or breaches the non-engineered dikes that are currently the only line of defense separating the bay from the community of Alviso and other people and property in the city of San Jose, CA. The consequences of a tidal flood event in the study area would be devastating: the community of Alviso is located at an elevation below mean high tide, and the region's largest water pollution control plant is located adjacent to the town and is also at risk from flooding. Thus, the answers to the first three questions posed above are relatively straightforward. The fourth question (likelihood) is the most challenging to answer, and requires the greatest level of effort and analysis.

The existing patchwork of non-engineered levees has to date prevented tidal flooding in the study area. These non-engineered levees had been constructed and maintained for years by private interests that were using the area for salt harvesting. These companies no longer own the land or operate in these ponds.

In order to understand the existing and future risk from coastal storm events, extensive coastal hydrodynamic modeling has been conducted. The modeling effort was made more complicated by the existence of non-engineered levees that traverse the study area. The modeling had to consider static water level, wave and tidal forces, dynamic and static failure of the existing levees, and overtopping volumes into the various ponds in the study area. All of these factors affect the estimate of water surface elevation at the innermost area of the bay adjacent to the populated area.

The without-project analysis of the flood risk estimates that there is currently a high annual likelihood of tidal flood damage in the study area. When considering the combined probabilities of water level at the outboard dike, failure of the outboard dike, and failure of the low inboard dike, in the year 2017 there is an approximate 32% chance of a damaging flood event in the study area. Given that that is only a few years from the time of writing, the current flood risk is thought to be practically equivalent.

Over time and in the absence of structural measures, under any of the future sea-level change scenarios such a high risk of flooding would be expected to eventually force residents and property owners from the floodplain. Exactly when and which residents would relocate is obviously highly uncertain, but it is only reasonable to conclude that, if faced with a high and steadily increasing future flood risk, property owners would not choose to or be allowed to rebuild or repair their structures after a significant flood event. How to incorporate these presumed relocations was one of the most challenging issues of this flood damage analysis.

Ultimately, the analysis applies some general assumptions about which structures would relocate and when. The relocations were tied to flood risk by assuming that any structure that sustains significant damage from an event with an annual chance of exceedance (ACE) of 10% or greater would relocate to a flood-free area. As the report describes in detail, once a structure was identified as having sustained significant enough damage that it would likely be relocated, the property was removed from the estimate of flood damage in subsequent modeling years.

The increasing likelihood of future coastal flooding in the area also threatens the San José-Santa Clara Regional Wastewater Facility (Wastewater Facility), which is a critical regional facility, and damage to it would be catastrophic on many levels. The Wastewater Facility serves approximately 1.4 million people and a large portion of the businesses in Silicon Valley. The plant is not in the current (year zero) coastal floodplains developed by USACE, but it is in the future floodplains that incorporate sea-level rise projections. Because this nearly $3 billion[2] facility is so important to the region, in the absence of a Federal project it is assumed that the City of San Jose would take measures to protect the facility from flooding. The cost of constructing a ring levee around this facility to reduce the risk of flood damage is estimated for planning purposes to be at least $25 million. Given that this cost is preliminary and for planning purposes only, the actual cost of implementing a stand-alone project to reduce the risk to the plant is likely greater. This planning estimate is simply incorporated in the analysis as a potential cost avoided as a result of construction of a comprehensive tidal flood risk management project.

As described above, the without-project analysis results indicate that there currently is a high probability of failure of the existing dike-pond system, and that the risk increases over time with a rise in relative sea level. In 2017 the annual chance of a damaging flood event is estimated to be 32%, and by 2067 the annual chance is estimated to be as high as 53%. Because of the low elevation of much of the properties in the floodplain (below mean sea level), a tidal flood event would cause significant property damage. If it reached the town, even water elevations associated with the more frequent flood events (50% ACE, etc), could cause tens of millions of dollars in property damage.

The without-project equivalent annual damage (EAD) from flooding over the entire 50-year period of analysis is estimated to be approximately $18.9 million, $23.6 million, and $42.1 million under the USACE Low, Intermediate, and High sea level change (SLC) scenarios.

Flood Risk Management Options & Benefits

The analysis evaluates nine flood risk management project options – the No Action Plan, seven structural options, and a non-structural option. The non-structural option analyzed involves the gradual but permanent evacuation of the floodplain and relocation of residents and businesses, and includes an assumption of the construction of a ring levee and other features to protect the SJ/SC WPCP. This non-structural option would leave the floodplain looking similar to what is expected under the long-term future without-project conditions (evacuation of floodplain and ring levee around the plant), the difference is that the evacuation would be completed before the flood risk increased significantly – possibly avoiding much of the adverse impacts to properties and human life and safety. Preliminary

[2] Estimated replacement value; source – SJ/SC WPCP

estimates of the cost of such a plan were in excess of $425 million[3]. A USACE value-engineering review during the study process recommended that, in the spirit of USACE planning modernization[4], because of the extremely high cost of implementation, no detailed analysis be conducted and no additional resources were devoted to considering this alternative. This report limits the analysis of the non-structural option to an estimate of the cost of implementation.

While several levee alignments were initially considered, it was ultimately determined that there was a single most efficient levee alignment for the FRM portion of the project. Because all of the levee alignments tie into the same high ground on both sides of the study area, and because all of the alignments are bayward of the developed area, the damages reduced are simply a function of levee height. The selection of levee alignment has cost and environmental implications, but not flood damage reduction implications. Thus, the detailed NED analysis was conducted on the most efficient levee alignment, at different levee heights. Levee heights between 10' and 15.2' were analyzed.

The with-project results for the three USACE SLC scenarios all show positive net benefits, ranging from approximately $15 million to $38 million in annual net benefits. All structural projects considered have strong economic justification under the three SLC scenarios considered. The benefit-cost ratios range from about 4 to 12 (at a discount rate of 3.375%). The optimum levee heights based on annual net benefits for the three SLC scenarios are 12.5' for the USACE Low and Intermediate SLC scenarios, and 13.5' for the USACE High SLC scenario.

Ecosystem Restoration Measures & Benefits

The project study authority is for both flood risk management and ecosystem restoration. Ecosystem restoration outputs are not quantified in monetary terms for USACE feasibility studies, so they cannot be directly combined with the quantified economic outputs of the project. What is quantified, however, is the cost-effectiveness of the restoration options, which is a way of identifying those options or features that provide the biggest "bang for the buck" in terms of restoration output. A restoration option is more efficient than another if it provides a) at least the same restoration output at a lower economic cost, or b) more restoration output at the same cost. This report also calculates the incremental cost of each cost effective restoration option. The incremental cost of an option is the additional cost of a plan over the cost of the next smallest option. In combination, this evaluation of environmental measures is known as cost-effectiveness (CE) and incremental cost analysis (ICA) or CE/ICA.

The analysis of the cost effectiveness and incremental cost of the restoration options shows that, not including the No Action option, there are six cost-effective options (also known as plans) and four "Best Buy" options or plans when considering restoration of all of the ponds in the study area[5]. Best Buy options are those that have the greatest increase in output for the smallest increase in cost. These options are a subset of the cost-effective plans that have the lowest incremental cost per unit of output. As discussed in the study's main integrated document, the CHAP model was not able to show additional environmental outputs for restoration measures beyond the baseline restoration of basic phased restoration

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[3] According to a relocation cost analysis performed by San Francisco District Real Estate and a ring levee cost estimated by HDR Inc.

[4] http://planning.usace.army.mil/toolbox/library/misc/StrongPoint%20-%20Civil%20Works%20Transformation%20-%20Planning%205%20APR%2012.pdf

[5] This includes ponds on USFWS land that may be restored by the USFWS or as part of the USACE project, pending WRRDA 2014 implementation guidance for Section 1025.

with a habitat "bench" (transitional habitat feature connecting upland and aquatic areas). In the case of the accelerated restoration measures that are considered, the lack of cost-effectiveness was due solely to the inability to obtain required predictions of future habitat conditions for this measure in GIS format under schedule and budget limitations. Thus, these conditions could not be input to the CHAP model to obtain results. Based on current ecological understandings, the environmental planners in the project delivery team (PDT) expect that there would, in fact, be an increase in annual habitat outputs as a result of accelerating the restoration process within the pond groupings (A9-A11, A12, A13-A15, A18).

According to USACE policy, in all but the most unusual cases, the NER Plan should be derived from the final set of Best Buy solutions. Other solutions, identified as non-cost effective in cost effectiveness analysis; as well as cost effective plans identified as relatively less efficient in production ("non-Best Buys") in incremental analysis, may continue to be considered for selection. The six cost-effective plans consist of combinations of basic phased restoration of the four pond groupings specified above. The four Best Buy plans involve basic phased restoration of subsets or all of the pond groupings. The NER option identified is the largest of the four options, which includes basic phased restoration of all of the pond complexes. This option has a greater average cost per habitat unit than the smaller plan, but is a large area of land and the inclusion of the additional pond complex has important environmental outputs that, according to the California State Coastal Conservancy, are critical to the regional restoration effort. However, most of the ponds in the area are owned by the U.S. Fish and Wildlife Service, and under current USACE policy they are not able to be part of a USACE project[6]. Pond A18, though, is owned by the City of San Jose, and thus can be restored as part of a cost-shared USACE project. The CE/ICA considers all of the ponds, but results are presented for both project options – all ponds or just A18. Restoration of A18 is a separable component and is one of the four Best Buy plans.

The Combined NED/NER Plan

The multi-purpose FRM and ER plan that is expected to provide the greatest net benefits and provide the best balance of outputs has been tentative identified as the is 13.5' flood risk management levee combined with the basic restoration of all of the study area pond complexes. The 13.5' levee height would significantly reduce coastal flood risk to the study area through the period of analysis under any of three SLC scenarios considered. It should be noted that the net benefits for a 12.5' and 13.5' levee are similar under the three SLC scenarios, and it is possible that the 12.5' levee scale may ultimately be designated as the appropriate levee scale for the NED plan. Corps planning guidance specifies that where two cost-effective plans produce no significantly different levels of net benefits, the less costly plan is generally identified as the NED plan, even though the level of outputs may be less.

The Combined NED/NER Plan, including the restoration of all ponds, has a total estimated first cost of about $105.8 million ($71 million for FRM and $34.8 million for ecosystem restoration). When only including the restoration costs for pond A18, the combined NED/NER plan has a total first cost of about $79.9 million ($71 million for FRM and $8.9 million for ecosystem restoration). For the FRM component of the Combined NED/NER Plan, net benefits range from $15.3 million under the low SLC scenario to $38.3 million under the high SLC scenario. Corresponding benefit/cost ratios range from 5.2 to 11.5.

[6] Section 1025 of the Water Resources Reform and Development Act of 2014 would allow for the USACE project to include restoration on USFWS lands – pending implementation guidance from USACE Headquarters.

For the NER component of the Combined NED/NER Plan, total average annual habitat units for the restoration of all ponds are estimated at 48,508 AAHUs. Total first and average annual costs are estimated at $34.8 million and $1.52 million, respectively. Average annual costs per AAHU are about $31. For just the Pond A18 restoration component of the Combined NED/NER Plan, total AAHUs are estimated at 14,577. Total first and average annual costs are estimated at $8.9 million and $389,000, respectively. Average annual costs per AAHU are about $27.

Locally Preferred Combined Plan

The locally preferred multi-purpose FRM and ER plan (LPP) includes a 15.2' flood risk management levee combined with the basic restoration of all study area pond complexes plus a 30:1 slope ecotone. The LPP has a total estimated first cost of about $158.8 million ($85.8 million for FRM and $73 million for ecosystem restoration). When only including the restoration costs for pond A18, the LPP has a total first cost of about $122 million ($85.8 million for FRM and $36.2 million for ecosystem restoration). For the FRM component of the LPP, net benefits range from $14.6 million under the low SLC scenario to $37.8M under the high SLC scenario. Corresponding benefit/cost ratios range from 4.4 to 9.8.

For the ER component of the LPP, total average annual habitat units for the restoration of all ponds are estimated at 48,508 AAHUs. Total first and average annual costs are estimated at $73 million and $3.2 million, respectively. Average annual costs per AAHU are about $66. For just the Pond A18 restoration component of the LPP, total AAHUs are estimated at 14,437. Total first and average annual costs are estimated at $36.2 million and $1.6 million, respectively. Average annual costs per AAHU are about $110.

The LPP is the Tentatively Selected Plan (TSP). However, as noted most of the ponds in the area are owned by the U.S. Fish and Wildlife Service, and under current USACE policy they cannot be included as part of a cost-shared USACE project. Therefore, the ER portion of the TSP includes only the restoration of Pond A18, since it is located on lands eligible to be included as part of the cost shared project.

1. Introduction

1.1. Purpose

The purpose of this report is to document the methodology and results of the economic analysis conducted to assess the socioeconomic impacts of various projects that have been proposed to reduce the flood risk and restore ecosystem function in the study area known as the South San Francisco Bay Shoreline. The study area consists primarily of the community of Alviso, located in the City of San Jose, California, but it also includes the largest water pollution control plant in the region – the San Jose/Santa Clara Water Pollution Control Plant (SJ/SC WPCP). Even though this is a multi-purpose project per the study authority, in order to understand and quantify the flood risk management benefits and costs, it is necessary to analyze that portion of the project separately before combining these features with ecosystem restoration features as part of a combined, multi-purpose project. The combined alternative that maximizes the sum of net benefits and best balances the mix of outputs will be identified as the NED/NER Alternative.

1.2. Guidance and References

The principal guidance referenced for this analysis comes from the U. S. Army USACE of Engineers (USACE) "*Planning Guidance Notebook*" (PGN), ER 1105-2-100, with specific guidance from Appendix D – Economic and Social Considerations. For the evaluation of the ecosystem restoration options: *Evaluation of Environmental Investments Procedures Manual* – IWR Report 95-R-1. Additional guidance on risk-based analysis has been obtained from USACE ER 1105-2-101, *Risk Analysis for Flood Damage Reduction Studies*, dated January 3, 2006. Guidance related to policies and procedures for incorporating future sea-level change was taken from EC 1165-2-212 (1 Oct 2011), *Sea-Level Change Considerations for Civil Works Programs*.

Benefits and costs are expressed in average annual terms at fiscal year 2014 price levels using the 2014 federal discount rate of 3.5%. The period of analysis is 50 years. The study/project Base Year, defined as the year when the project is expected to be operational and benefits begin to be realized, is assumed to be 2017[7].

1.3. Flood Damage Analysis Overview

By policy, USACE Flood Risk Management feasibility reports must evaluate potential measures to reduce the risk of flooding against four "accounts." These are National Economic Development (NED), Regional Economic Development (RED), Environmental Quality (EQ), and Other Social Effects (OSE). The USACE Planning Guidance Notebook (PGN) describes the NED account as follows:

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[7] This year was established early on in the study process and was used in the coastal modeling. In reality, given funding and construction timelines, the year in which flood risk management benefits would be realized is more likely closer to 2020. However, since the economic impacts are measured in real dollars, as long as the construction timeline is appropriately treated (interest during construction calculation), shifting the base year assumption has little or no effect on the results of the flood damage analysis. For consistency's sake it was decided to use 2017 as the Base Year throughout the integrated feasibility and environmental impact statement document.

> *Contributions to national economic development (NED) are increases in the net value of the national output of goods and services, expressed in monetary units. Contributions to NED are the direct net benefits that accrue in the planning area and the rest of the Nation. Contributions to NED include increases in the net value of those goods and services that are marketed, and also of those that may not be marketed.*

The NED account is exclusively concerned with national net economic benefits, and thus does not include local or regional economic transfers. For example, according to the PGN, the prevention of income loss results in a contribution to national economic development only to the extent that such loss cannot be compensated for by postponement of an activity or transfer of the activity to other establishments. More details on the NED account and the evaluation procedures for flood risk management projects can be found in the PGN.

This report focuses primarily on quantifying the trade-off between NED benefits and costs for various project alternatives including the no action option, structural options, and a non-structural option. Nonstructural measures or options are defined in the PGN as follows:

> *Nonstructural measures reduce flood damages without significantly altering the nature or extent of flooding. Damage reduction from nonstructural measures is accomplished by changing the use made of the floodplains, or by accommodating existing uses to the flood hazard. Examples are flood proofing, relocation of structures, flood warning and preparedness systems (including associated emergency measures), and regulation of floodplain uses.*

While the NED categories evaluated may differ between alternatives, the primary NED categories evaluated in this analysis are as follows:

- Structure and Content Damages
- Cost to Temporarily Displaced Residents
- Cost to Relocate Residents
- Cost to Reduce the Flood Risk to the San Jose Santa Clara WPCP

The damage and damages reduced to structures, contents, and the cost of residential displacement are all estimated within the computer program HEC-FDA v.1.2.5a (FDA), while damages related to the other categories were estimated outside of the FDA program. This version of the FDA program is the most up to date and is a USACE-certified planning tool. For those damage categories calculated in FDA, the value of these assets was estimated outside of the program, and then imported into the program along with probability-stage data for each particular structure or automobile. The base structure elevation data (not including a first floor adjustment) was provided to the USACE San Francisco Economics Section by the Geographic Information System (GIS) Section.

The FDA models were built with data for each structure, under each scenario, and for each of the eight annual chance exceedance (ACE) events – 50%, 20%, 10%, 4%, 2%, 1%, .4% and .2% events. This report uses the term "annual chance exceedance" (ACE) to describe the likelihood associated with storm and flood events. The ACE is the reciprocal in percentage terms of what is often referred to as the “return period.” The return period (or recurrence interval) of an annual maximum flood event has a return period of X years if its magnitude is equaled or exceeded once, on the average, every X years. For example, a 100-year return period means that, on average, it is expected that a storm of that magnitude or greater would occur once every 100 years. The inclusion of the phrase "on average" in that definition means that it is possible to have more than one (or zero) 100-year event over any number of years - or even in the same year. The description of likelihood in "return period" terms has in recent years been supplanted by percentage-based terminology. This shift has occurred because it is believed that describing the likelihood in annual percentage terms is more precise and less prone to misinterpretation. In this report, what has been known as the "100-year" storm or flood event is described as having an ACE of 1%.

The analysis was conducted by directly inputting the water surface elevations in the bay – at the outboard dike – into FDA as the water surface profile. A levee failure function was entered into the FDA model for each without-project condition model. A relationship between the elevation of water in the bay and the elevation of water in the community of Alviso was also specified in the model. This information was developed by the team's coastal engineer. FDA calculates the depth of flooding at each structure for each event and develops the aggregated stage-damage curve. With the structure inventory elevation and first floor elevation data, FDA uses Monte Carlo simulation to calculate a flood stage-damage relationship with uncertainty. Expected annual damages are then derived based upon a Monte Carlo simulation that accounts for the exceedance probability/stage function (with uncertainty), the stage/damage relationships (with uncertainty), and the geotechnical "fragility" function, which specifies the probability of failure by elevation for the existing outboard dike. Simulation results include both expected annual damages as well as probabilistic distributions for each year analyzed.

Equivalent annual damages represent the annualized net present value of damages over the 50-year period of analysis. The HEC-FDA model is capable of computing equivalent annual damages when there are only two years analyzed (e.g., a Base Year and Future Year). Since more than one model was used for this analysis (five decadal models for the without-project condition for each SLC scenario), the computation of equivalent annual damages had to be completed outside of the FDA program; the HQUSACE-approved spreadsheet for annualizing was used ('AverageAnnual&IDC_2010').

The flood damage analysis was completed for three sea level change scenarios – Low, Intermediate, and High. These scenarios come from USACE guidance, and more on the three scenarios can be found in the Coastal Engineering Summary (Appendix E) as well as from the USACE Engineering Circular 1165-2-212. Having three scenarios makes the reporting of the results somewhat challenging. In order to minimize the reporting requirements, in some cases this report will describe the results of just one scenario (Intermediate), but the final results and those most important to the planning decision will be reported for all three future scenarios.

Additional details can be found in the sections that follow.

1.4. The Study Area

The study area is a mix of residential, industrial, and commercial structures. This area includes Alviso, a community of approximately 2,100 residents and 580 housing units. The community is located just adjacent to the bay and has been significantly impacted in the past by riverine flood events.[8] Alviso is at a very low elevation, and as a result significant damage is expected to occur at in-basin water surface elevations (WSEL) of just over 5 ft (NAVD 88). The study area includes the San Jose Santa Clara WPCP, an elementary school, and a City of San Jose Fire Department Station. Figure 1 shows the study area

[8] The Guadalupe River Park Conservancy (http://www.grpg.org/flood-control) notes Guadalupe River flooding in San Jose's downtown and Alviso community, with severe flooding in 1862, 1895, 1911, 1955, 1958, 1963, 1969, 1982, 1986 and 1995.

location. The area labeled "Reset Interim Study Area" is the focus of this study effort, which is a subset of the larger study area that will likely be considered in future feasibility study efforts.

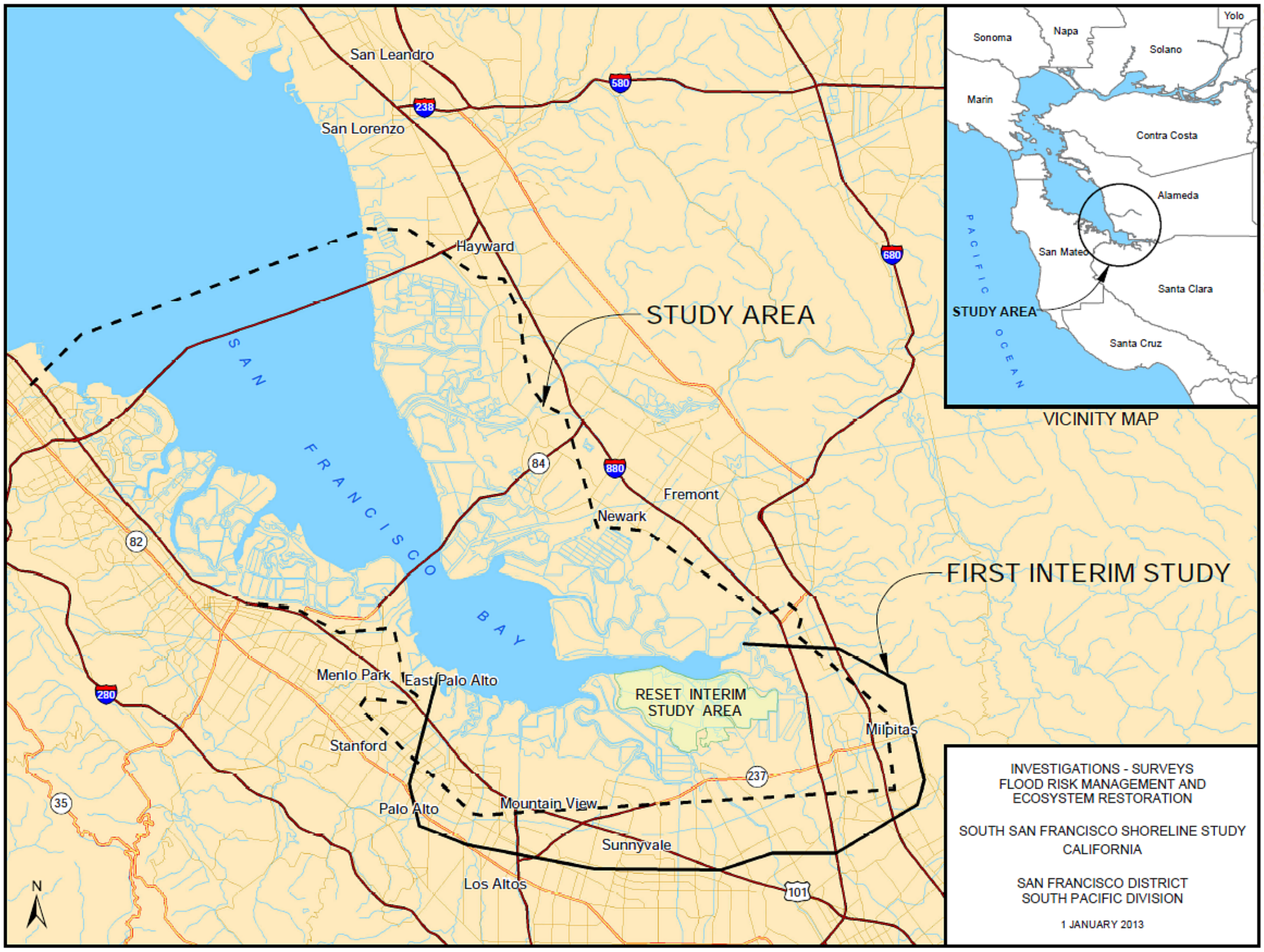

Figure 1: Location of Study Area

The study area's residents are mostly low-income, minority individuals and families. More than half of the residents are Hispanic or Latino, and about 15% are Asian. As Table 1 (Comparison of Selected Economic Indicators) shows, the area lags behind the surrounding counties and the state on several measures of economic performance.

Table 1: Comparison of Selected Economic Indicators

Category	Local Census Area*	Santa Clara County	Alameda County	San Mateo County	California
Median Household Income	$52,202	$86,850	$69,384	$85,648	$60,883
Unemployment Rate	12.4%	8.2%	8.9%	6.8%	10.5%
Percentage of Population at or Below Poverty Level	15.6%	8.9%	11.4%	7.0%	13.7
Sources: State/County: 2010 Census, State of California. **Alviso**: US Census, American Community Survey. *Census Tract 5046.02					

1.5. Historical Flooding

The community of Alviso not only lies at the edge of the bay but also is straddled by the Guadalupe River to the west and Coyote Creek to the east. Both drain to the bay. The study area has not historically suffered damages from coastal flooding. However, the area has been flooded by waters from the Guadalupe River, which overtopped its banks in 1983, resulting in significant flood damage in the community of Alviso. Since then, the levees along the Guadalupe River have been raised (project completed in 2004), and many of the homes in the community have been raised several feet. Currently the annual risk of fluvial flooding in the community is estimated to be less than 1%.

2. Without-Project Flood Risk

The coastal floodplain includes all of the community of Alviso as well as dozens of homes and businesses further inland. The community of Alviso is at an elevation of approximately 4 feet, which just above the mean sea level of about 3.7 feet . The properties in the study area are at an elevation of between 1 and 14 feet (not accounting for raises to the finished floor), with approximately one quarter of them being less than 4 feet above sea level. The increasing future coastal flood risk poses a threat to the safety and health of the residents in the area. According to the coastal flood modeling, depending on the SLC scenario, flood depths within the community of Alviso could be as high as 7 to 10 feet within the fifty-year period of analysis.

2.1. Population at Risk (PAR)

One measure of flood risk often reported in the population at risk (PAR). This is a broader measure of risk than just those residing in the floodplain; it includes the number of people working in the area that are at risk of being adversely impacted by a flood event. Adding the number of people estimated to be working in the floodplain[9] (3,400) to the number of residents in the floodplain (2,100), the total PAR in the study area is estimated to be approximately 5,500 not including those persons traveling through the study area.

2.1. Property at Risk

In terms of number of structures, the study area is dominated by residential structures (see Table 2: Structure Types in 0.2% ACE Floodplain). The 0.2% ACE floodplain under the USACE High SLC scenario has approximately 1,100 structures, of which the vast majority is residential. There are several manufactured and mobile home parks, and several business parks with large commercial and industrial properties. The floodplain contains a school, several churches, a fire station (the structure is elevated out of the floodplain), critical infrastructure such as Highway 237 and the San Jose Santa Clara Water Pollution Control Plant (SJ/SC WPCP), and a wide range of commercial and industrial buildings – including many high technology and Information Technology (IT) companies. Cisco Systems, Inc. is the most well-known company located in the floodplain; their worldwide headquarters is located across Highway 237 in the study area.

Table 2: Structure Types in 0.2% ACE Floodplain

Residential	Commercial	Industrial	Public	Total
1,034	54	42	9	1,140

The colored areas shown in Figure 2 (Land Use in the Study Area) represent parcels with structures in the study's damage analysis inventory. The extent of the inventory was based on the 0.2% ACE floodplain extent of the USACE High SLC scenario at the end of the period of analysis (Year 50). The floodplain extent under the other two SLC scenarios is similar because of the flat topography in the study area and the relatively small difference in water surface elevations.

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[9] According to the site www.officespaceheaven.com, a rule of thumb for the amount of office space needed for each employee is between 175 and 250 square feet. From the assessor data collected for this study, there is estimated to be 830,000 SF of office space in the floodplain. If the average vacancy rate for commercial office space in the county (12.8%) is applied, the total square footage in use is estimated to be 726,000. Using the midpoint of the range of square feet per employee (212.5), the total number of persons working in the floodplain is roughly estimated to be 3,400.

For presentation purposes, the land use map only shows four general land use categories, but the structure inventory database and the flood damage analysis contain 20 different structure types.

Figure 2: Land Use in the Study Area

Figure 3 displays the approximate elevations of the properties in the study area (NAVD88). As the figure shows, most of the community of Alviso is below 5 feet.

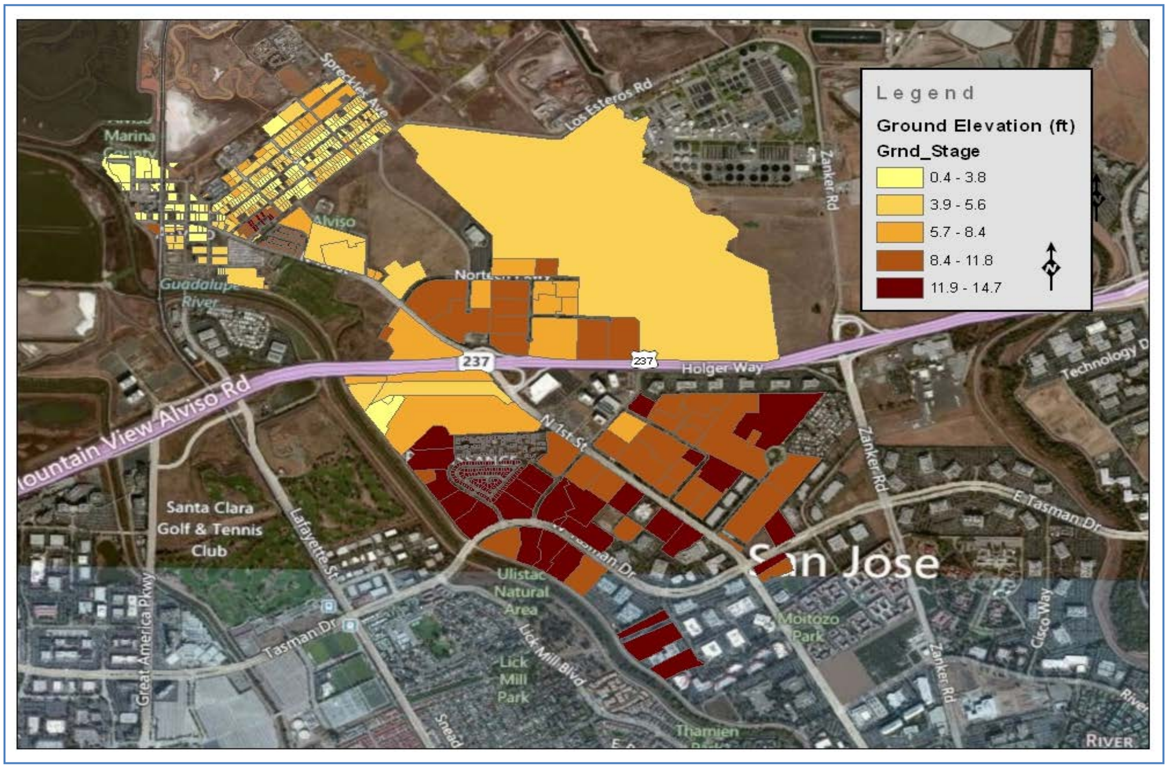


Figure 3: Ground Elevation of Parcels in Floodplain

2.2. Structure & Content Valuation

The parcels identified as located within the 0.2% ACE floodplain were matched to data downloaded from the First American Core Logic database. This real estate database includes parcel-specific information on structure type, square footage, construction date, information on improvements, etc. The vast majority of the residential structures inventoried fit into the Class D category. Class D buildings are characterized by combustible construction. The exterior walls may be made up of closely spaced wood or steel studs, as in the case of a typical frame house, with an exterior covering of wood siding, shingles, stucco, brick, or stone veneer, or other materials. They may also consist of an open-skeleton wood frame on which some form of a curtain wall is applied including the pre-engineered pole or post-frame buildings.

For the valuation of the structures in the floodplain, structures were classified into one of the following 20 categories listed below:

- Single Family Residential (SFR) 1-Story
- Single Family Residential 2-Story
- Multi-Family Residential (MFR) 1-Story
- Multi-Family Residential 2-Story
- Manufactured Housing (MH)
- Retail 1-Story
- Non-Medical Office, 1 Story
- Non-Medical Office, 2 Story
- Medical Office
- Restaurant - Fast Food
- Restaurant - Not Fast Food
- Grocery and Gas Station
- Schools - Wood Frame
- Schools – Masonry
- Public - Wood Frame
- Public – Masonry
- Light Industrial - Masonry
- R&D – Masonry
- Repair Shop - Masonry
- Warehouse – Masonry

The calculation of structure value in a floodplain can be done in several different ways, each having their advantages and disadvantages. One method, estimating the Depreciated Replacement Cost of the structures in the floodplain, involves integrating the following: size of the structure, the unit cost of construction as measured in cost per square foot, and an allowance for deterioration as measured as a percent of total value. An alternative way of calculating the total structure value in the floodplain would be to use tax assessment records on each parcel's improvement value. While this assessment information is readily available, California's Proposition 13, which limits increased assessments until a home is sold, results in unequal valuations of one home relative to another. It is primarily for this reason that this study will use the Depreciated Replacement Cost method. More information on the different structure valuation methods can be found in IWR Report 95-R-9, *Procedural Guidelines for Estimating Residential and Business Structure Value for Use in Flood Damage Estimations*. The Depreciated Replacement Cost method requires visits to the structures themselves in order to attain the necessary information, which includes foundation height, structure type, and structure condition. This process is explained below.

The valuation of the structures in the floodplain requires information on structure type, construction quality, current condition, and number of stories[10]. Once collected, this information was utilized to calculate the structure depreciated replacement values. Base per square foot construction cost estimates for each structure type were determined by utilizing the Marshall and Swift Real Estate Valuation Service method according to the following procedure:

- Construction quality and current condition of the structures were noted from field surveys.
- For a given structure type, the per square foot construction cost (replacement cost) was determined using the most current Marshall & Swift Valuation Service data. This per square foot cost estimate reflects the construction quality of the structure.
- The per square foot costs, which are based on a national average, were modified to reflect local cost conditions using Marshall & Swift local cost multipliers.

[10] Structure first floor elevation was also recorded for each structure visited as part of the field inventory work. While this data is not relevant for the structure valuation, it is a critical variable in the estimate of flooding damage.

- This current, locally adjusted cost per square foot was then adjusted additionally for the condition of the structure, which determines the appropriate depreciation factor to apply. In order to correlate the current condition of the structure to a percent depreciation, the study utilized Tables 7 through 9 of IWR Report 95-R-9, '*Procedural Guidelines for Estimating Residential and Business Structure Value for Use in Flood Damage Estimations*'.
- The depreciated replacement cost per square foot values were multiplied by square footage to arrive at the total depreciated replacement value for the different types of structures. If the square footage was not available within the real estate records for a particular property, square footage estimates were made from aerial photography measurements using the Google Earth application.

Figure 4 below shows residential structures typical in the study area.

Figure 4: Example of Residential Structures in the Study Area

Table 3 (Structure and Content Value in 0.2% Floodplain) below shows the estimated structure and content value for each of the major structure categories in the 0.2% ACE floodplain (rounded for presentation purposes). In total, about more than $800M of structures and contents are exposed to some level of flood risk by the end of the period of analysis. This value should not be confused with event-based or expected flood damage.

Table 3: Structure and Content Value in 0.2% Floodplain (FY14 Price Levels)

Structure Type	Total Structure Value (1,000s)	Total Content Value (1,000s)
Commercial	$333,038	$297,407
Industrial	$70,615	$47,145
Public	$5,068	$1,841
Residential	$56,753	$27,892
Total	**$465,474**	**$374,285**

The area has a history of flood damage from overflows from the Guadalupe River[11]. As a result, many of the residences have been rebuilt or raised significantly so that the finished floor elevation is as much as six feet or more above the ground.

As described above, under this study's methodology, the value of the contents within each structure is assumed to be a function of the value of the structure. The value of the contents of each structure was estimated by multiplying the Content Structure Value Ratio (CSVR) for the particular structure type by the estimated structure value (as calculated per the method described in the previous section).

Table 4 (CSVRs per Structure Type) shows the ratios assumed for the content-to-structure values of the different classifications of residential and non-residential buildings in the floodplain. For consistency's sake the CSVRs for the non-residential structures were taken from the same source as the saltwater structure and content depth-damage curves.

Table 4: CSVRs per Structure Type

Structure Type		CSVR	Standard Deviation	Source
Residential	SFR	0.5	0.12	1
	MFR	0.5	0.12	1
	MH	0.5	0.12	1
Commercial	Eating and Recreation	0.4	0.65	2
	Groceries & Gas Stations	1.42	0.65	2
	Professional Businesses	0.9	0.9	2
	Retail and Personal Services	1.71	1.45	2
Other	Industrial	0.68	0.98	2
	Public	0.37	0.48	2
Sources: 1 - Per limit specified in ER 1105-2-100; 2 - Expert Panel Meeting, Houma, Louisiana, February 13, 1997				

For structure and content damages, depth of flooding relative to the structure's first floor is the primary factor in the magnitude of the damage. The GIS database, provided by Santa Clara County and Alameda County, contained spatially referenced polygons for each parcel in the study area. Each parcel was then assigned a centroid in order to determine the ground elevation at the parcel, which was taken from the latest available Digital Elevation Model. A parcel centroid is the point that represents the geographic center of mass of a parcel.

The USACE San Francisco GIS Section ran statistics on the elevation of each of the parcel centroids (NAVD88), and provided the Economics Section with data tables containing these elevations. No

[11] The levees along the Guadalupe River in the study area were raised in the 2004, reducing the risk from flooding to fluvial events larger than the 1% ACE event.

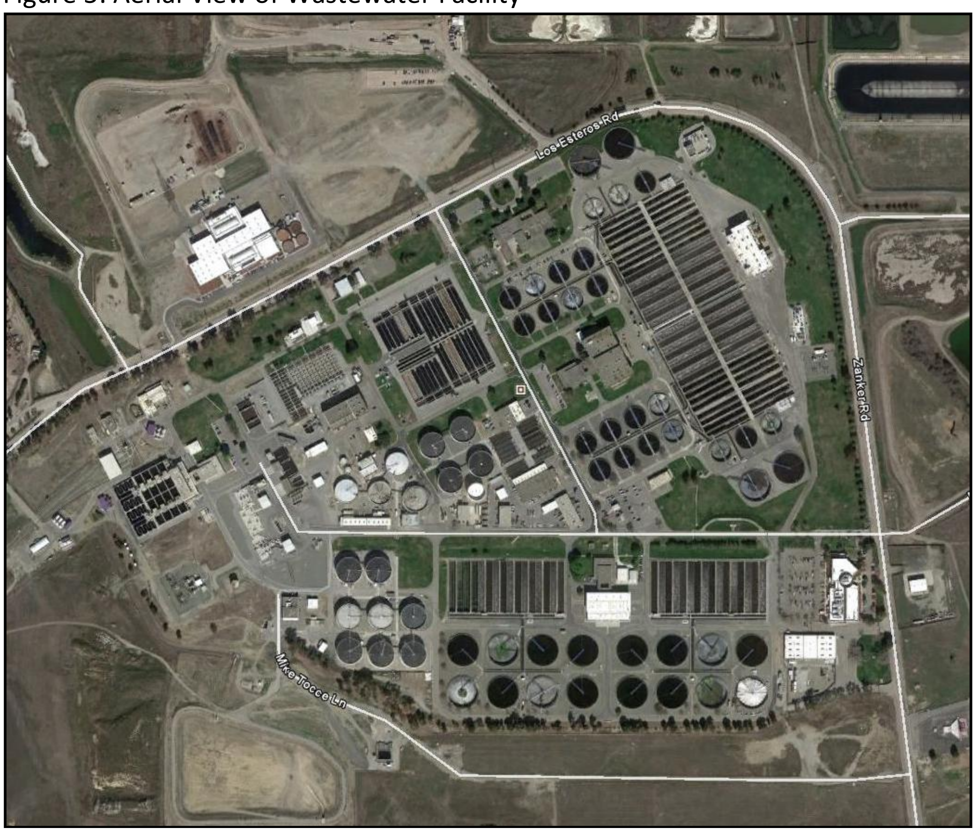
uncertainty was applied to these elevations, but as described below uncertainty was applied to the estimate of the extent to which the first floor of the structures has been elevated.

The elevation of each structure in the study area - along with an adjustment for the first floor elevation (FFE) - were combined with economic data (structure and content value, automobile value, displacement cost, etc.) and imported into the FDA model. For residential structures, a representative sample of first floor heights was observed in the field and applied with uncertainty to the population of structures. For residential structures the uncertainty in FFE was entered in the FDA model as a normal distribution with a 0.5 foot standard deviation. For the non-residential structures, which tend to have similar and small raises to the first floor, the complete inventory was observed in the field. The standard deviation of the normal distribution for non-residential structures was set to 0.3 feet based on professional judgment.

2.3. Impacts of Flooding at the San Jose-Santa Clara Regional Wastewater Facility

The Wastewater Facility is by far the largest water treatment facility in the region, serving 1.4 million people and around 16,000 businesses. The facility has a capacity of approximately 170 million gallons per day (gpd). According to a 2009 analysis conducted for the city of San Jose by the consulting firm CH2M Hill, the plant has a total estimated replacement value of approximately $2.8 billion. Figure 5 shows an aerial view of the facility. The facility is approximately one-half mile from the bay.

Figure 5: Aerial View of Wastewater Facility



Source: Google Earth, 2014

The plant is currently outside of the 1% ACE floodplain, but within the 0.2% ACE floodplain. With sea level rise the plant will be at much greater risk within the next few decades. Current floodplains developed by the USACE show that floodwaters would reach the plant when flood waters from the bay reach approximately 10 feet (NAVD88). According to the flood risk analysis, the combined annual probability of that elevation in the bay and a failure of the existing outboard dike is approximately 1%. Under the USACE Intermediate SLC scenario, the annual likelihood of that same event occurring in the year 2067 is approximately 15%. See Table 8 for more information.

If flood waters were to reach the plant, the economic and environmental impacts would be catastrophic. The following description of the reaction to a flood threat and of the potential damage that would occur if flood waters reached the plant were developed with the assistance of personnel at the WPCP.

In the event of a flood, the WPCP would first take measures to insulate critical mechanical and electrical components to prevent inundation. These measures include placing sandbags and soil at entrances to pump stations or motor control centers to act as a physical barrier between flood waters and vital operational equipment. Temporary sump pumps would drain any flood waters that seep in. If flooding of the equipment seems inevitable, mechanical and electrical components would be turned off immediately, resulting in limited to no treatment capabilities during the flood threat. Shutting down these components would help to reduce damage to equipment and shorten overall operational downtime in the event that flood waters inundated parts of the plant. Actually implementing these measures would require special means of transportation for plant employees depending on flood depths.

When flood waters recede, any components exposed to flood water must be removed and taken off site to undergo a baking/drying process in order to be restored to full functionality. Once thoroughly dried out, the components go through an exhaustive testing and decommissioning phase. During this process, the WPCP is expected to shut down for a 2 to 3 month period unless temporary components are installed while the permanent fixtures are restored to working order. If mechanical and electrical components are not shut off before inundation, however, the impacts to the equipment and plant operation will be more significant. Mechanical and electrical components would likely require replacement, which takes 6 to 12 months for procurement and installation.

During larger flood events, the WPCP would likely shut down. The ramifications of a plant shut down include the inability to treat raw sewage and a lack of availability of recycled water to local customers who depend on it for the cooling of machinery during industrial processes. These customers include local power providers. In general, large flood events that result in plant shutdown will lead to potential sewage overflows in the communities served by the plant, degradation of the bay, and a shutdown of recycled water customers. Sewage releases into the bay would result in significant environmental damage and large fines.

There are no standardized depth damage curves or established methodologies for determining a) the value of structural/mechanical/electrical damage from flooding to these types of facilities, or b) the economic impact to the serviced communities from a decrease or cessation of waste water treatment services of various lengths of time. Working with personnel from the WPCP, a detailed accounting was compiled of the estimated flood damage to each separate facility or structure that is exposed to flood damage at the plant. Since much of the plant's electrical systems are located underground, very significant damage is expected to occur at even very shallow flood depths at the plant. The following is a list of assets that would be significantly exposed to damage from a flood event that reached the plant.

- Pump Stations
- Plant Computer System
- Treatment Areas
- Headworks
- Digesters
- Cogeneration Facilities
- Operation & Maintenance Building
- Tunnels

According to officials from the WPCP, the damage to these assets from a flood event that at least inundates the underground facilities is estimated to total more than $250 million. This does not include the impacts and costs to health and human safety and the environment from a release of raw sewage into the bay, the cost of fines imposed by the local and state agencies, nor does it include the impact of a loss of service to homes and businesses in the region.

Given the financial, safety, and environmental impacts of a damaging flood event at the plant, it is reasonable to assume that in the absence of a larger Federal project the City of San Jose would invest in flood risk reduction measures at the plant, which would most likely consist of a ring levee and associated features. To be clear, the City of San Jose has stated that they do not currently have an alternative plan for reducing flood risk to the plant in the absence of a federally-sponsored levee project. Nonetheless, it is important to consider what the City might do rather than just assume no future action and count all expected flood damage over the period of analysis. A preliminary, planning-level estimate of the cost of a ring levee shows the construction would cost $25 million not including real estate. This cost is included in the estimate of the cost of the non-structural alternative as well as the value of the damages reduced for the structural alternatives.

2.4. Impacts to the Union Pacific Railroad (UPRR)

A line of rail track owned by Union Pacific Railroad (UPRR) runs through the study area and project area. With sea level rise this rail line is expected to be at risk of coastal storm damage. The damage could be in the form of additional maintenance and repair costs, restricted use (or closure) of the line, or both. However, because a large segment of the track runs through the ponds north of the study area, unless measures are taken to elevate the entire track in a way that reduces the impact of sea level rise, none of the proposed alternatives would benefit the railroad. For this reason the impacts to the UPRR have not been included in this report.

2.5. Flood Damage Modeling in HEC-FDA

The HEC-FDA program is used to combine water surface profile data and economic data (structure inventory, etc.) in order to derive a stage-damage function for each reach or impact area. HEC-FDA version 1.2.5a was used, which is a USACE certified model, and its use complies with EC 1105-2-407 (*Planning Model Improvement Program: Model Certification*).

The major inputs to the flood damage model are shown below in Figure 6 (Major Inputs to the HEC-FDA Models). They include the water surface profile, levee failure function, interior-exterior flood elevation relationship, value and location of assets in the floodplain, and the relationship between depth of flooding and structure and content damage.

Figure 6: Major Inputs to the HEC-FDA Models

WATER SURFACE PROFILE*	• Water surface elevation and probability • Source: Coastal Engineer
LEVEE FAILURE FUNCTION	• Likelihood of outboard dike failure at each water surface elevation • Source: Geotechnical Engineer
INTERIOR-EXTERIOR RELATIONSHIP*	• Relationship between water elevation in the ponds and Alviso - accounting for pond storage • Source: Coastal Engineer
ASSETS IN THE FLOODPLAIN	• Value and elevation of structures and assets • Source: Economist - field surveys
DEPTH-DAMAGE RELATIONSHIP	• Relationship between depth of flooding and damage to structures and contents • Source: USACE EGM and other feasibility studies

**Denotes inputs that change with sea level change*

The consideration of sea level change complicates the damage analysis because under each of the scenarios the flood risk is continually increasing into the future. In a typical HEC-FDA model, a Base Year and a single Future Year would be entered into the model. The program then assumes a linear relationship between the Base Year and the Future Year conditions that have been specified in the model. However, because of the existence of the current patchwork of salt pond levees, because future sea level change is not expected to be a linear function of time, and because of the need to consider the impact of structure relocations out of the area over the period of analysis, the traditional approach to flood damage modeling in HEC-FDA is not appropriate for this analysis.

Instead, for this analysis, for each sea level change scenario the fifty-year period of analysis was separated into five without-project models – one for each decade of the analysis.

2.5.1. HEC-FDA Input 1: Water Surface Profile

Updated water surface profile data was developed for each of the three SLC scenarios – USACE Low, Intermediate, and High. To reasonably capture the change in water surface elevations over time as a result of sea level change, data was provided for project year zero (2017) and for every tenth year thereafter over the fifty-year period of analysis. Also, in order to account for the impact of pond storage, an interior-exterior relationship was developed for each event at each time interval. This is important since the water surface elevation at the outboard dike (exterior) is not expected to always be equivalent to the elevation of floodwater that reaches the developed area (interior). A plot of the water elevations over the period of analysis for each probability event is shown below for each SLC scenario in Figure 7 through Figure 9 below. In the figures, the 0.99 ACE event corresponds to an annual likelihood of 99%, and the 0.002 corresponds to an event that has a one in five hundred chance of occurring in any given year.

Figure 7: Water Surface Elevation at Outboard Dike over Time by Return Interval (USACE Low SLC Scenario)

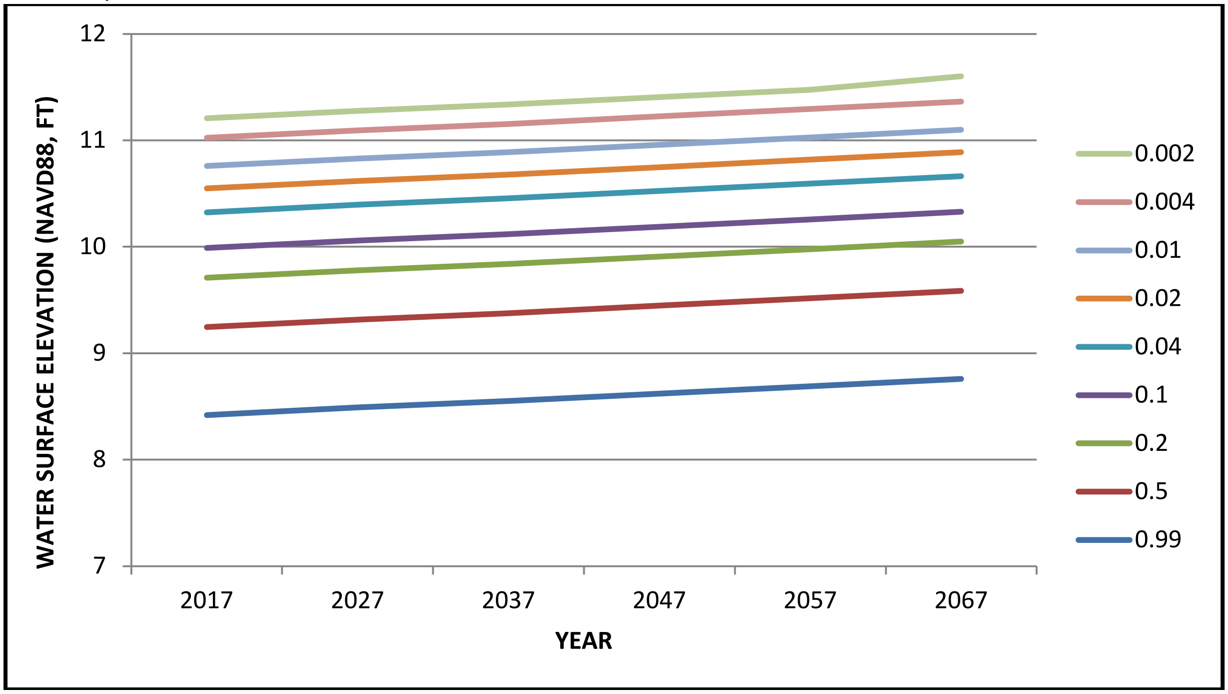


Figure 8: Water Surface Elevation at Outboard Dike over Time by Return Interval (USACE Intermediate SLC Scenario)

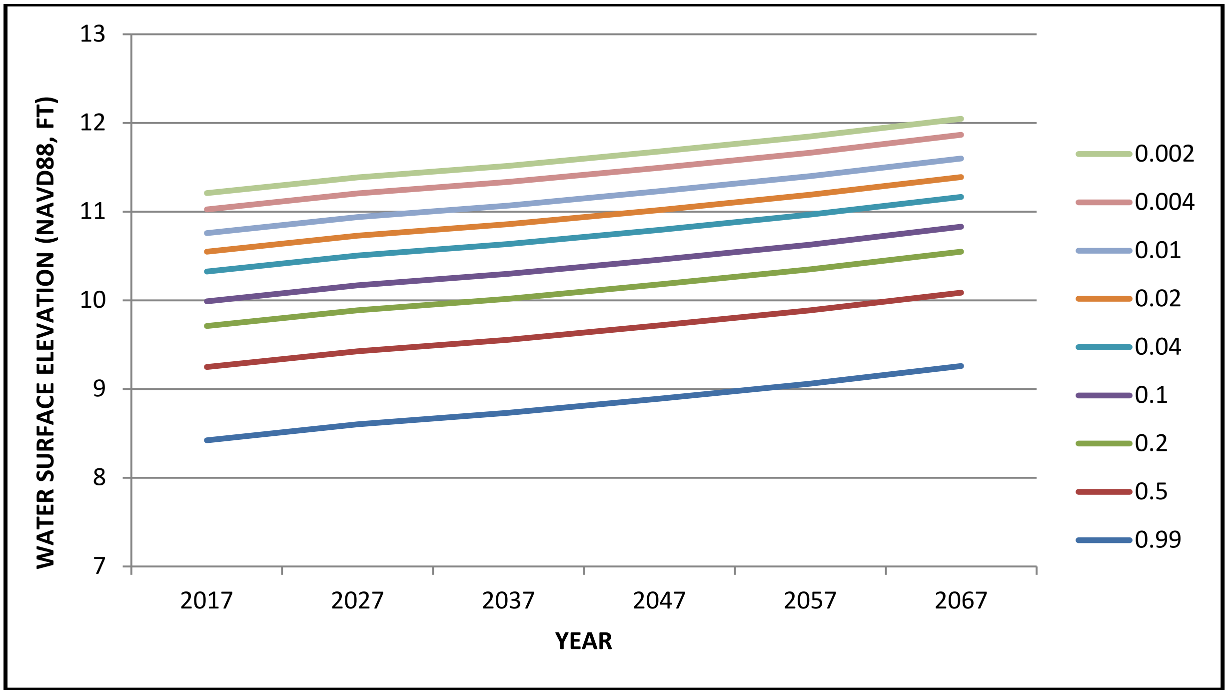
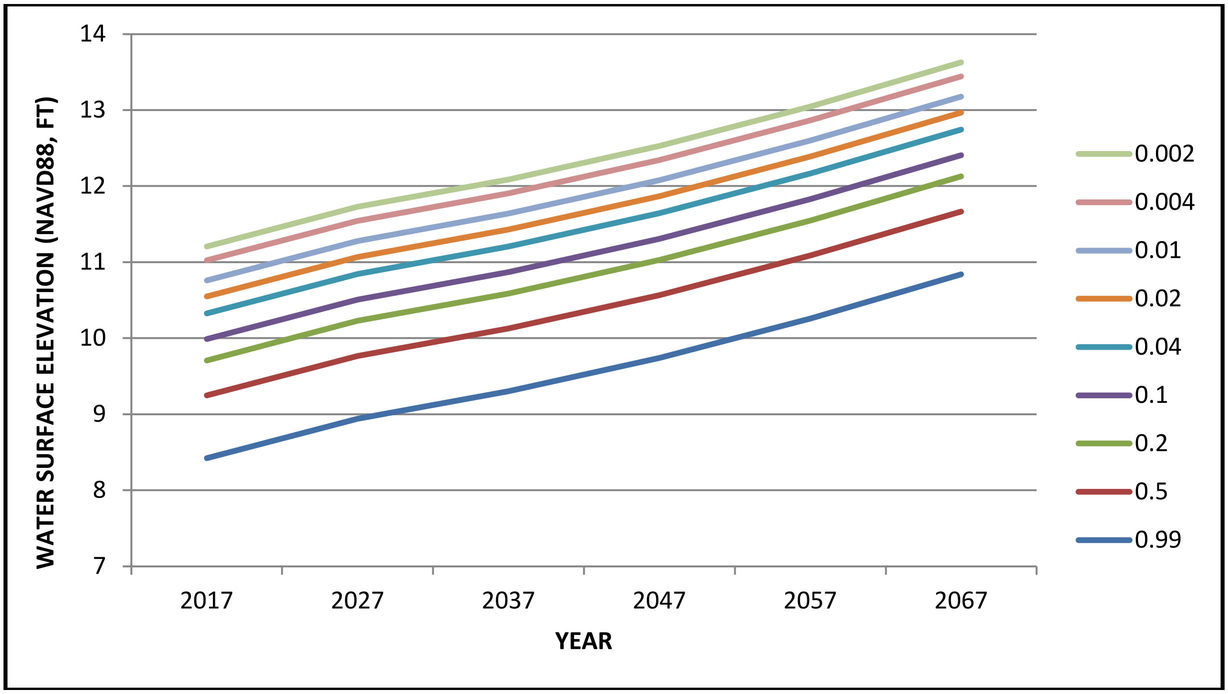


Figure 9: Water Surface Elevation at Outboard Dike over Time by Return Interval (USACE High SLC Scenario)



2.5.2. HEC-FDA Input 2: Dike Failure Function

A levee failure function, which indicates the probability of levee failure given a particular water surface elevation, was developed for the outboard pond dike to be used in the HEC-FDA models. A plot of the data entered into the HEC-FDA models is shown in Figure 10 (Dike Failure Function) below. More details on the development of the levee failure function can be found in the Geotechnical Investigation and Analysis Appendix (Appendix O) of the feasibility report.

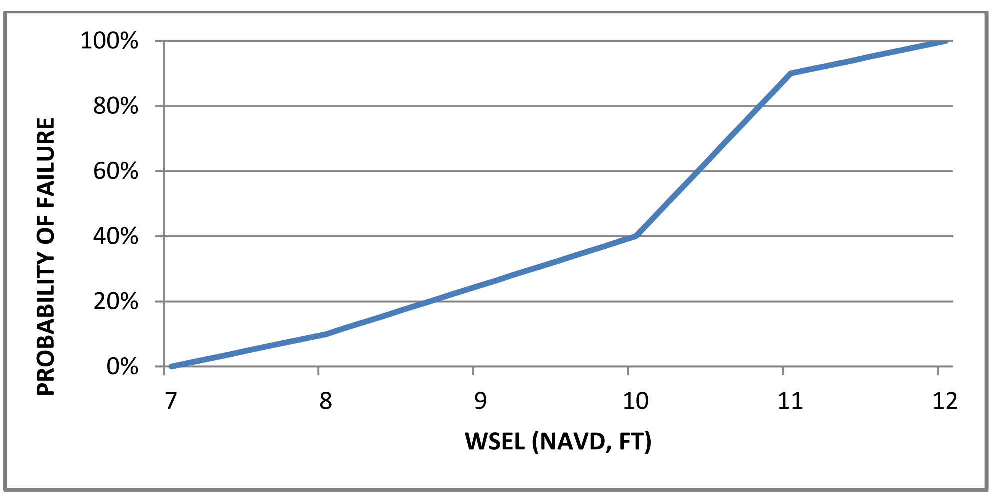


Figure 10: Dike Failure Function

2.5.3. HEC-FDA Input 3: Interior-Exterior Flooding Relationship

A breach of the outboard pond dike would not necessarily result in an equivalent elevation of flood water in the developed area of the basin (i.e., community of Alviso or near the water pollution control plant). The pond system between the outboard dike and the developed area would provide a limited amount of storage. Unless told otherwise, the HEC-FDA model assumes that the flood elevation in the developed area is equivalent to the outboard elevation at the time of dike failure. Not accounting for the storage in the ponds would generally result in an overestimation of the flood elevation and damage. For this reason, it was necessary to develop a relationship between the exterior water elevation at the outboard dike and the interior water elevation in the developed area in the event of a flood event. FDA uses the term "interior" to describe the floodplain, and "exterior" to describe the location where the source of water is located – in this case the bay. This relationship was entered into the HEC-FDA model.

The difference between the exterior and the interior water surface elevation varies over time, by annual chance of exceedance flood event, and by SLC scenario, but is generally between zero and two feet. The difference in elevation generally decreases as the events get larger (less likely) because the ponds would fill up faster during larger events. However, there is a scenario in which the interior flood elevation may be greater than the exterior elevation that resulted in the initial dike breach. For example, this can happen when a dike failure occurs at a water surface elevation that is below the astronomical high tide. In this situation the pond storage may be sufficient to keep water from overtopping the inner dike and ponding in the developed area, but because the dike-pond system would then be open to the bay waters, subsequent high tides would be expected to overtop the inner dike (which is considerably lower than the outer dike in some places) and result in flooding in the developed area. Specifically, an outer dike breach that occurs at an exterior elevation of 7' would be expected to eventually result in an interior water elevation equivalent to mean high tide, which is 7.8' at the base year and increases over time under all future scenarios considered. More details on the development of the interior-exterior water surface elevation relationship can be found in the Coastal Engineering Summary (Appendix E) to the feasibility report.

2.5.4. HEC-FDA Input 4: Floodplain Assets

The assets in the floodplain are described in detail in Sections 2.1 through 2.3 above.

2.5.5. HEC-FDA Input 5: Depth-Damage Relationships

Flooding can cause significant damage to structures of all types. Water can cause a structure's structural components to shift or warp – including the studs and foundation. Water can also damage the wiring, gas lines, and septic system. For high water, ceilings may sag under the weight of trapped water or soggy drywall, wet floorboards can bend and buckle, and the roof may leak or break altogether. Flooding in a basement can be especially dangerous; if the water is removed too quickly, pressure from the soaked earth outside can push inward and crack the foundation walls. Most of the structures in the floodplains that are studied in this analysis are wood frame, and this type of structure will suffer greater exterior damages than those made of brick or masonry. In all types of residential housing, though, flooding will most likely destroy the interior walls. Soaked wallboard becomes so weak that it must be replaced, as do most kinds of wall insulation, and any plywood in the walls is likely to swell and peel apart. Water can also dissolve the mortar in a chimney, which creates leaks and thus a risk of carbon monoxide poisoning once the heat comes back on.

Also, floods often deposit dirt and microorganisms throughout the house. Silt and sediment can create short circuits in the electrical system as residue collects in walls and in the spaces behind each switch box and outlet. Appliances, furnaces, and lighting fixtures also fill with mud, making them dangerous to use. Anything that gets soaked through with water may contain sewage contaminants or provide a substrate for mold. Most upholstered items must be thrown away, as well as carpets and bedding.

Damages to structures, contents, and vehicles were determined based on depth of flooding relative to the structure's first floor elevation. The depth-damage relationships assign loss as a percentage of value for each parcel or structure. The deeper the relative depth, the greater the percentage of value damaged. The sources of the relationships were different depending on structure type.

In this study, the damage from flooding is exacerbated because of the corrosive effects of saltwater. A 1997 report by Gulf Engineers and Consultants for the USACE New Orleans District describes the effect of saltwater on structures and contents.

> *According to the panel of experts, saltwater causes more damages and quicker damages than freshwater. Saltwater is more corrosive on metal items. Contents that remain in saltwater for over one day will eventually begin to rust unless the items can be washed, but that is not cost-effective.*
>
> *Saltwater also damages wood quicker than freshwater. Salt causes discoloration and markings on content items due to the salinity of the water. According to the expert panel, to the human eye everything appears to be okay when the water is going down. Saltwater damages those little unnoticeable things such as screws that hold on wiring, toggle switches inside mechanisms, all of these things appear to be fine until they are examined months later. Saltwater does not necessarily have to touch the items to cause damage. For example, if saltwater gets close to an item it will still have the corrosive effect. The atmosphere is concentrated with salt so when it evaporates the salt does not stay down. The salt becomes part of the mist or the moisture in the room.*
>
> *Saltwater damages light fixtures, door hinges, and other various contents. With evaporation, the salt becomes more concentrated. Eventually paint will start to flake off, recliners will not close, recliners will begin to squeak, mechanisms fail and salt line residuals will be left on the contents. The blinds may not be save [sic] in saltwater as compared to freshwater because of the residual damages.*

According to the USACE engineers, depending on the circumstances, it is possible that, because of relatively poor interior drainage, flooding in the basin could persist for more than a single day - depending on the mechanism of flooding (breach or overtop). Both long-duration and short-duration saltwater curves have previously been developed by the USACE New Orleans District. These curves were developed with the hot and humid Louisiana climate in mind, and since the long-duration curves are where the effects of humidity are mostly reflected, the short-duration saltwater curves are believed to more accurately depict the effect of saltwater flooding on structures and contents in the Shoreline study area. The short-duration saltwater curves were developed by the New Orleans District for the Donaldsonville to the Gulf Feasibility Evaluation in April of 2006.

The depth-damage relationships for the primary structure types and their contents are shown in the figures below.

SFR1 and SFR2 stand for Single Family Residential 1-Story and 2-Story, respectively. The freshwater curves are taken from USACE Economic Guidance Memorandum (EGM) 04-01, and are shown for comparison's sake. The saltwater depth-damage curves were taken from the previously-referenced Expert Panel Meeting in Houma, Louisiana on February 13, 1997. The curves have a triangular uncertainty distribution, and the upper and lower bounds are shown in each of the graphs below (Figures 11 through 18). The curves for the Displacement category were taken from FEMA's '*Full Data Module for Benefit-Cost Analysis of Riverine Hazard Mitigation Projects, Mitigation BCA Toolkit CD, Version 2.0, January 2005*'

Figure 11: SFR1 Structure Depth-Damage Curve

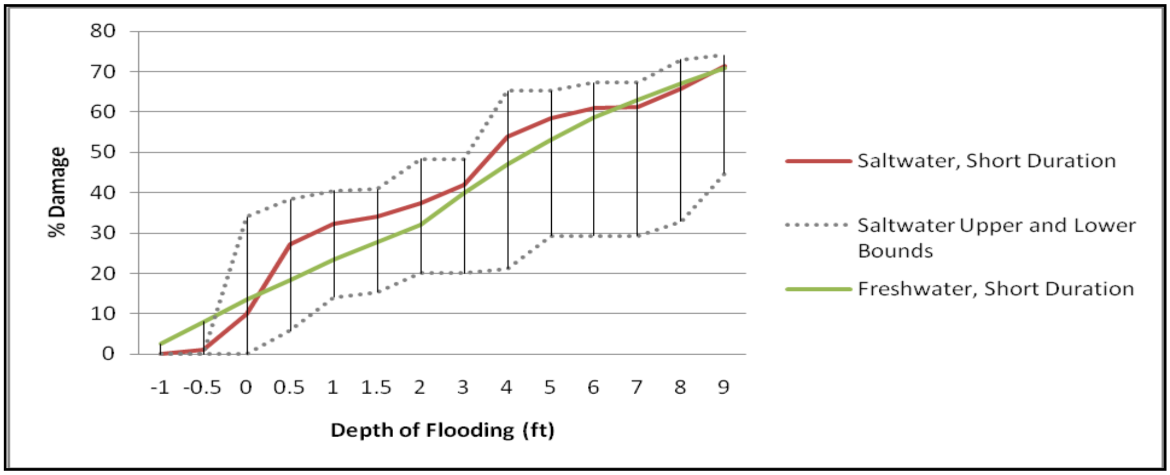


Figure 12: SFR1 Content Depth-Damage Curve

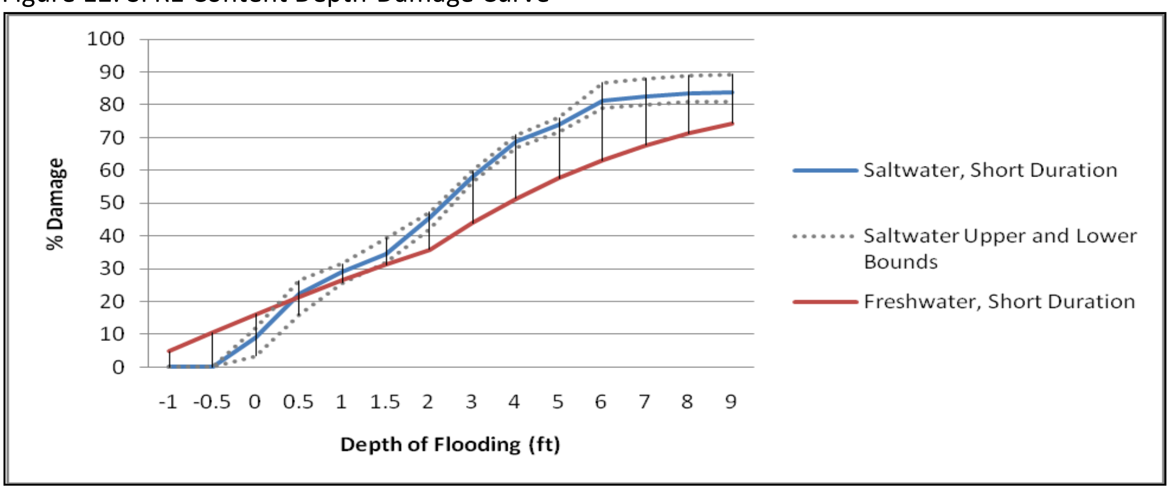


Figure 13: SFR2 Structure Depth-Damage Curve

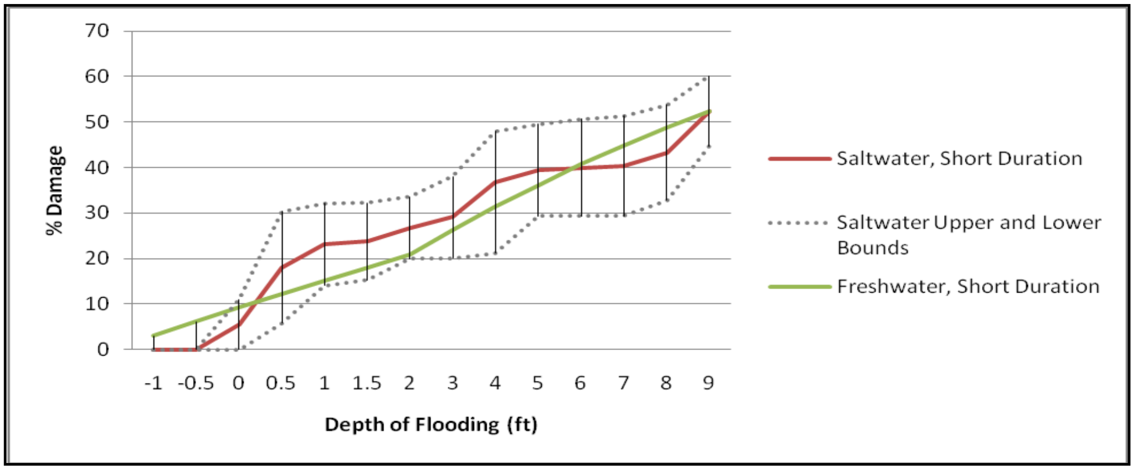


Figure 14: SFR2 Content Depth-Damage Curve

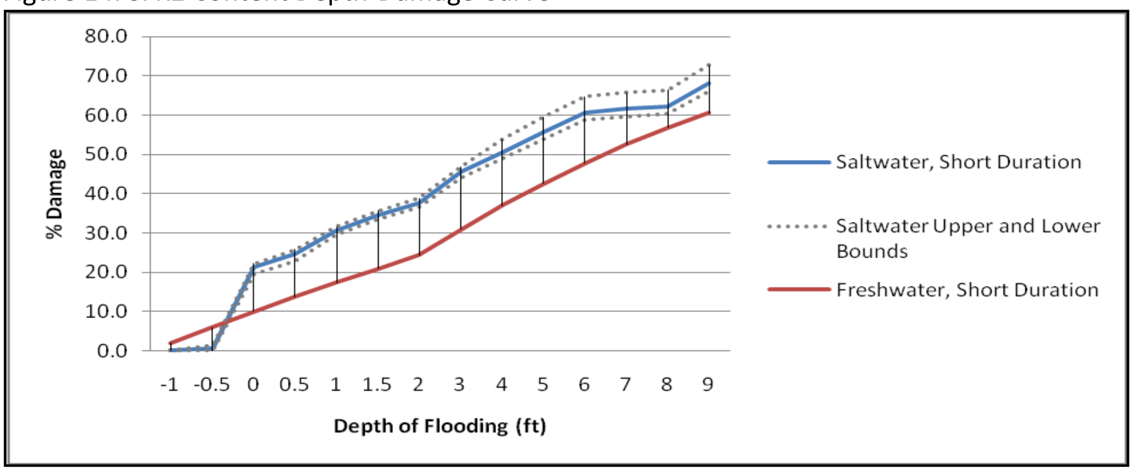


Figure 15: Commercial Structure Depth-Damage Curve

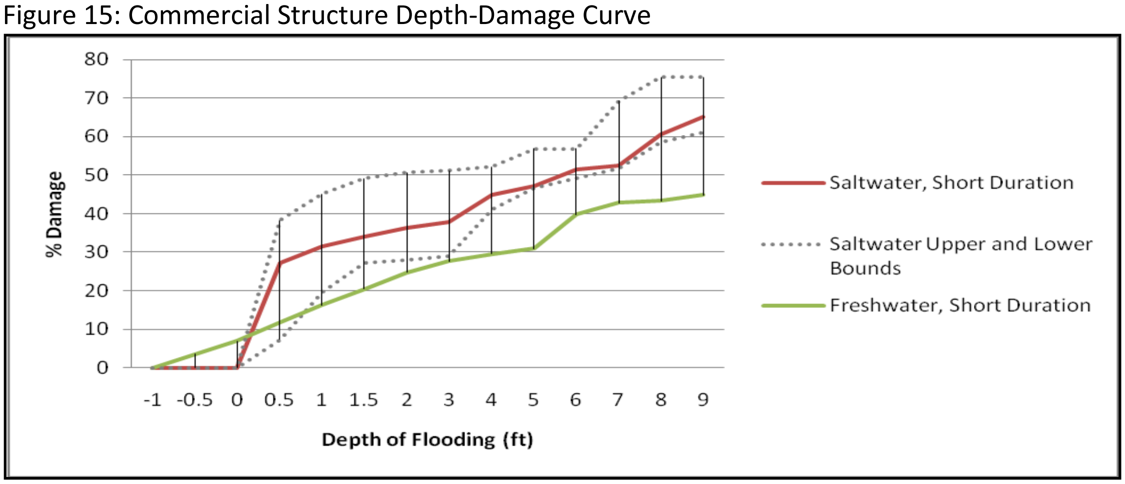


Figure 16: Commercial Content Depth-Damage Curves

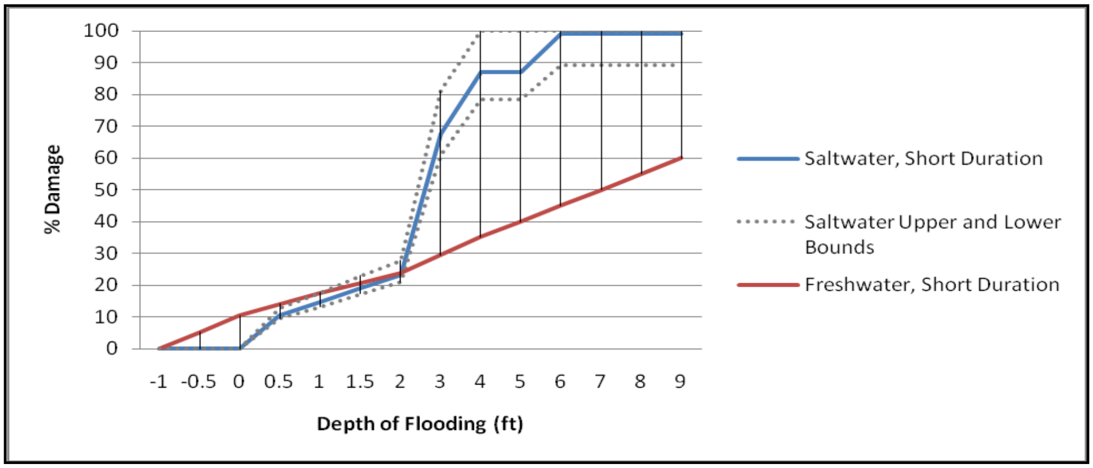


Figure 17: Industrial Structure Depth-Damage Curve

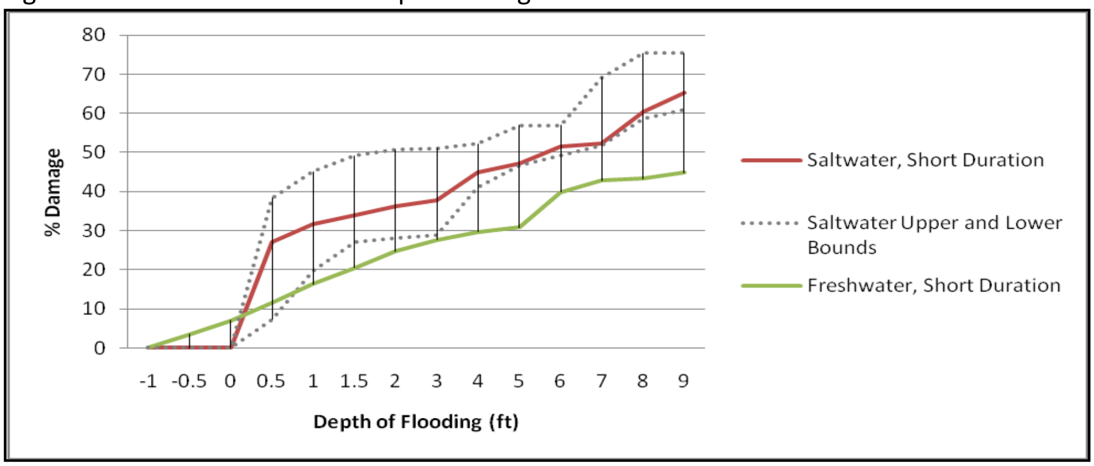
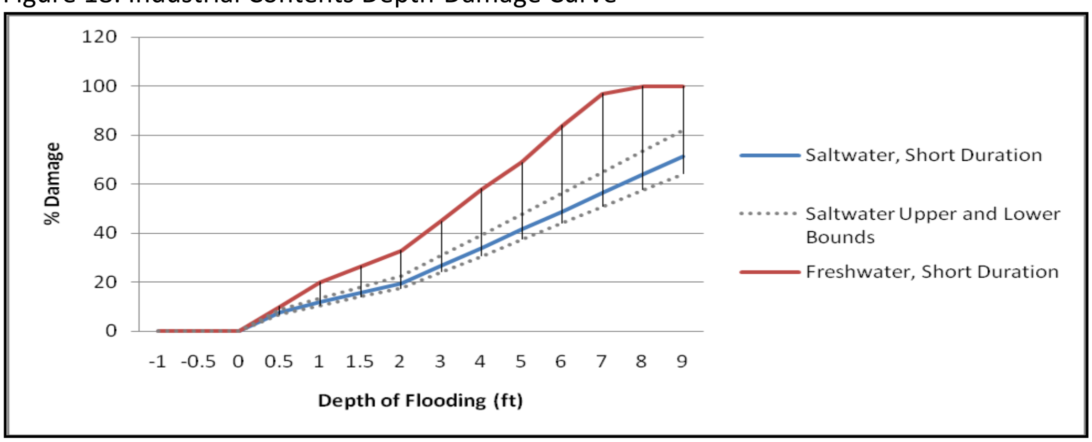


Figure 18: Industrial Contents Depth-Damage Curve



Displacement costs were estimated for the relocation and emergency services provided for those displaced both during the peak flood event and during post-flood structural renovations. In order to estimate displacement costs, it is necessary to make assumptions regarding a) the level of structure damage from flooding that generally results in temporary displacement, b) the relationship between structure damage and displacement time, and c) the percentage of households that would be forced to find rental accommodations versus the percentage that would stay with friends or family. To this end, the analysis uses an algorithm contained in FEMA's '*Full Data Module for Benefit-Cost Analysis of Riverine Hazard Mitigation Projects, Mitigation BCA Toolkit CD, Version 2.0, January 2005*'.

This algorithm has the following features:

- If building damage is <10% of building replacement value, displacement time is zero.
- If building damage is 10%, displacement equals 30 days.
- If building damage is >10%, displacement time is 30 days plus 8 days for each one percent increase in building damage above 10%.
- Displacement time is capped at 365 days.

According to this approach, for example, 30% building damage results in a displacement time of 30 days plus 20 times 8 days, for a total of 190 days. The 365-day cap on displacement means that occupants of buildings with more than about 50% damage (52%) are assumed to be typically displaced for one year. Given that a structure that is over 50% damaged would have to be extensively renovated or rebuilt, a year of displacement seems reasonable.

No specific study has yet been conducted by the USACE to determine how to estimate the percentage of displaced households that would be forced to rent alternative accommodations versus the percentage that could relocate. The current analysis makes the simplifying assumption that half of the displaced households would be able to temporarily relocate at little or no direct cost – that is, with family or friends.

The remaining variable in the equation for the estimate of total displacement costs are the monthly rental and one-time relocation costs. For the purposes of this analysis, $2,000 is assumed as the total furnished monthly rental rate, and is based on the results of internet research on the cost of rental properties in the area. The one-time cost of moving is assumed to be $500. The result is a maximum cost of $24,900 was determined and used as the total value imported into HEC-FDA, (cost if displaced for 1 year). Uncertainty parameters applied for Displacement Costs were 10% about the mean for value and 0.5 ft foundation height – the same as used for the structures themselves. These functions were calculated by relating the depth of flooding to the percent damage to the structure, to the number of days per the FEMA algorithm, to the cost associated with that number of days, to the proportion of a full year displacement that the displaced number of days represents. Depth-damage figures for Displacement Costs are shown below (Figures 19 and 20).

Figure 19: Displacement Cost and Days Displaced

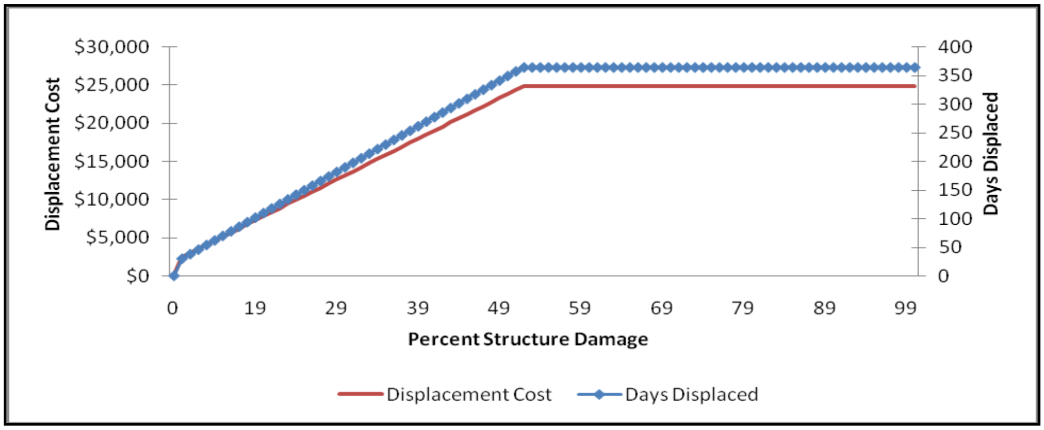
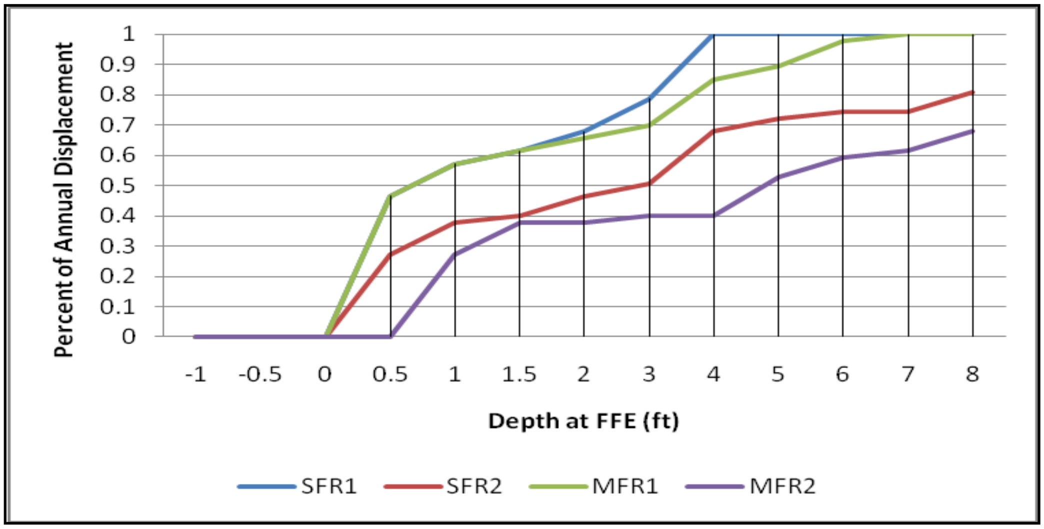


Figure 20: Displacement Depth Damage Curve



2.6. The Flood Hazard – Combined Probability of Flooding

Table 5 (Flood Hazard over Time – USACE Intermediate SLC SLC Scenario) displays how the flooding hazard in the study area increases over time under the USACE Intermediate SLC scenario. Multiplying the probability of the water surface elevation occurring in a given year by the probability that this elevation will cause a failure of the outboard non-engineered dike (which is the primary line of defense currently) results in a probability of a certain elevation of floodwater reaching structures, infrastructure, and people in the study area. In Table 5, “exterior” elevation refers to elevation at the outboard dike, and “interior” elevation refers to water surface elevation in the developed area. In 2017, which is the base year for this study, there is just greater than a 1% chance of getting a flood event with 9.5 feet of water in Alviso. By the end of the 50-year period of analysis (the year 2067), the annual probability of getting that same flood elevation in Alviso is 16%. This increase is due to the increase in relative sea level at the study location. An equivalent table (not included in the report) has been produced for the other two USACE SLC scenarios and similarly displays increases in coastal flood risk over time.

Table 5: Flood Hazard over Time – USACE Intermediate SLCSLC Scenario

	ACE of Exterior Elevation (Outboard Dike)	99%	50%	20%	10%	4%	2%	1%	0.4%	0.2%
2017	Exterior Elevation (ft)	8.42	9.25	9.71	9.99	10.32	10.55	10.76	11.02	11.21
	Prob. of Levee Failure	0.16	0.28	0.355	0.385	0.55	0.65	0.75	0.9	0.92
	Interior Elevation (ft)	7.81	7.81	7.81	7.81	9.34	9.49	9.63	11.02	11.21
	Combined Annual Prob. of Flooding	16%	14%	7.1%	3.9%	2.2%	1.3%	0.75%	0.36%	0.18%
2027	Exterior Elevation (ft)	8.60	9.43	9.89	10.17	10.50	10.73	10.94	11.20	11.39
	Prob. of Levee Failure	0.19	0.31	0.37	0.45	0.65	0.75	[illegible]	[illegible]	0.93
	Interior Elevation (ft)	7.99	7.99	7.99	8.5	9.4	[illegible]	[illegible]	[illegible]	[illegible]
	Combined Annual Prob. of Flooding	19%	16%	7.4%	4.5%	2.6%	1.5%	0.85%	0.37%	0.19%
2037	Exterior Elevation (ft)	8.73	9.56	10.02	10.30	10.63	10.86	11.07	11.33	11.52
	Prob. of Levee Failure	0.205	0.325	0.4	0.5	0.7	0.8	0.9	0.93	0.95
	Interior Elevation (ft)	8.12	8.12	8.5	9.5	9.8	10.6	11.07	11.33	11.52
	Combined Annual Prob. of Flooding	21%	16%	8%	5%	2.8%	1.6%	0.9%	0.37%	0.19%
2047	Exterior Elevation (ft)	8.89	9.72	10.18	10.46	10.79	11.02	11.23	11.49	11.68
	Prob. of Levee Failure	0.22	0.355	0.45	0.6	0.75	0.9	0.92	0.94	0.96
	Interior Elevation (ft)	8.28	8.28	9.45	9.65	10.4	11.02	11.23	11.49	11.68
	Combined Annual Prob. of Flooding	22%	18%	9%	6%	3%	1.8%	0.92%	0.38%	0.19%
2057	Exterior Elevation (ft)	9.06	9.89	10.35	10.63	10.96	11.19	11.40	11.66	11.85
	Prob. of Levee Failure	0.25	0.37	0.55	0.7	0.85	0.91	0.93	0.96	0.98
	Interior Elevation (ft)	8.45	8.45	9.78	10.49	10.96	11.19	11.4	11.66	11.85
	Combined Annual Prob. of Flooding	25%	19%	11%	7%	3.4%	1.8%	0.93%	0.38%	0.20%
2067	Exterior Elevation (ft)	9.26	10.09	10.55	10.83	11.16	11.39	11.60	11.86	12.05
	Prob. of Levee Failure	0.28	0.4	0.65	0.8	0.91	0.93	0.95	0.98	1
	Interior Elevation (ft)	8.65	8.65	10.55	10.83	11.16	11.39	11.6	11.86	12.05
	Combined Annual Prob. of Flooding	28%	20%	13%	8%	3.6%	1.9%	0.95%	0.39%	0.20%

A 1% ACE Flood Event at 2017 is a 16% Event by 2067

2.7. HEC-FDA Model Results

2.7.1. Expected Annual Damage

Table 6 (Expected Annual Flood Damage, USACE Intermediate Scenario) below shows the expected annual damage as calculated in the HEC-FDA models for the USACE Intermediate SLC scenario. The decrease between any two years (2026 and 2027 for example) is a result of including the relocation over time of structures according to the algorithm described in the paragraphs below. Without the assumption of structure relocations, the HEC-FDA model results would be significantly higher than shown below, as a large number of structures would sustain significant flood damage repeatedly. The Addendum at the end of this appendix details the without project exceedance probability/damage functions by decade generated by the HEC-FDA model, which when combined with the exceedance probability/stage functions and getotechnical fragility curves in the Monte Carlo simulation process, result in the expected annual damage results as presented below.

Table 6: Expected Annual Flood Damage, USACE Intermediate Scenario (1,000s) – FY14 Price Levels

Year	Commercial	Displacement	Industrial	Public	Residential	Total
2017	$4,845	$471	$2,542	$553	$2,945	$11,356
2026	$7,181	$617	$3,109	$675	$3,691	$15,273
2027	$6,799	$373	$418	$255	$2,230	$10,075
2036	$10,383	$515	$565	$292	$2,712	$14,467
2037	$9,421	$419	$568	$46	$2,200	$12,654
2046	$12,716	$527	$662	$52	$2,564	$16,521
2047	$12,189	$388	$608	$52	$1,763	$15,000
2056	$21,343	$848	$887	$85	$3,262	$26,425
2057	$14,363	$680	$44	$17	$1,948	$17,052
2066	$23,421	$1,234	$69	$33	$3,466	$28,223

Using the decadal HEC-FDA models for each scenario, if a structure's first floor elevation was 1.5' or more below the 10% ACE event water surface elevation for ten years, then that structure was removed from all future HEC-FDA models. For residential structures, 1.5' of flooding above the first floor elevation corresponds to structure damage equal to between one-quarter and one-third of the value of the structure. Thus, the algorithm considers both the frequency of flood damage and the severity of damage. Over ten years, the chance of experiencing at least one 10% ACE event is 65%, and the chance of experiencing two or more is 26%.

Table 7 (Structure Relocations over Time –– USACE Intermediate SLC Scenario) and Figure 21 (Structure Relocations over Time –– USACE Intermediate SLC Scenario) below show the relocations over time according to the algorithm specified above and under the USACE Intermediate SLC scenario.

Table 7: Structure Relocations over Time – USACE Intermediate SLC Scenario

Structure Type	Year					
	2017	**2027**	**2037**	**2047**	**2057**	**2066**
Residential	1035	951	927	884	832	822
Commercial	54	49	48	45	43	42
Industrial	42	22	21	19	15	14
Public	9	5	3	3	2	2
Total Structures	1140	1027	999	951	892	880
Cumulative Relocations	NA	113	141	189	248	260

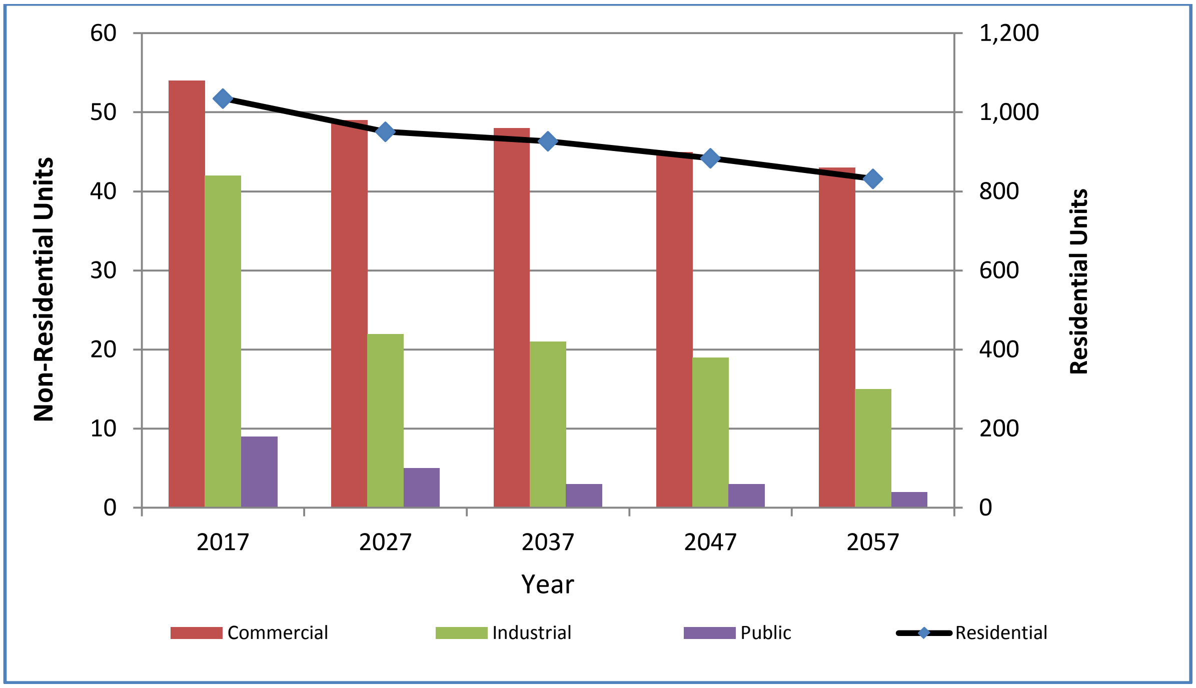


Figure 21: Structure Relocations over Time – USACE Intermediate SLC Scenario

The cost of relocating to similar properties outside of the floodplain was included in the ultimate expected annual damage (EAD) calculations performed outside of the HEC-FDA model. The cost per structure was estimated by USACE Sacramento District Real Estate personnel in 2012. Adding the cost of structure relocations increases the total expected annual damage shown in Table 6 by approximately 50% - from $15.4M to $22.5M.

In addition to considering the cost of relocations, the without-project damage analysis considers the cost to reduce the flood risk to the San Jose-Santa Clara Regional Wastewater Facility. The facility serves 1.4 million people and thousands of businesses, and is the largest treatment facility in the region. In the absence of a structural project to keep coastal storm water from reaching the basin, it is assumed that, because of its economic and environmental importance, actions would be taken to reduce the likelihood of damage to the facility. A ring levee surrounding the plant was estimated to cost $25M to construct. It was assumed that in the face of increased coastal flood risk the ring levee would be constructed by 2027.

Table 8 (Example of Without-Project Total EAD Calculation –– USACE Intermediate SLC Scenario) below shows an example of how the total EAD is calculated for each year of the period of analysis. The table only shows eleven years of the period of analysis, for illustrative purposes. For each year, the damages from all of the damage categories are summed and the present value is calculated using the applicable discount rate. The values for the intervening years between the beginning and end of each HEC-FDA model's 10-year analysis intervals were calculated by interpolation. The sum total of the annual present values is then annualized to calculate an equivalent annual damage.

Table 8: Example of Without-Project Total EAD Calculation – USACE Intermediate SLC Scenario (1,000s)

Year of Project	Year	Present Value Factor	EAD From FDA Model	Relocation Cost	Ring Levee Construction	Total	Present Value
0	2017	1.000	$11,356	$0	$0	$11,356	$11,356
1	2018	0.966	$11,791	$0	$0	$11,791	$11,392
2	2019	0.934	$12,226	$0	$0	$12,226	$11,413
3	2020	0.902	$12,661	$0	$0	$12,661	$11,420
4	2021	0.871	$13,096	$0	$0	$13,096	$11,413
5	2022	0.842	$13,532	$0	$0	$13,532	$11,393
6	2023	0.814	$13,967	$0	$0	$13,967	$11,362
7	2024	0.786	$14,402	$0	$0	$14,402	$11,320
8	2025	0.759	$14,837	$0	$0	$14,837	$11,268
9	2026	0.734	$15,273	$0	$0	$15,273	$11,206
10	2027	0.709	$10,075	$168,484	$25,000	$203,559	$144,306

The total equivalent annual damage (which is the term used for the calculation of expected annual damage for damage that is changing over the period of analysis) for the fifty-year period of analysis under the USACE Low, Intermediate, and High SLC scenarios is $18.2M, $22.6M, and $40.2M, respectively. These values are expressed at FY14 price levels and were computed based upon a 3.5% discount rate.

2.7.2. Event-Based Damages

According to the HEC-FDA model results, currently, a 10% ACE flood event would cause more than $100M in structure and content damage, and a 1% ACE event would cause more than $200M in damage. With sea level rise the damage will go up under all of the three SLC scenarios. The damages are so high for even more frequent flood events because of the low elevation of many of the properties in the floodplain; much of the area is below mean sea level.

3. Flood Risk Management Options

In the earlier phases of the feasibility study, the FRM options included both structural and non-structural measures, with structural options (levee construction) located along several different alignments through the study area. The alignments were all located north of the town of Alviso and the WPCP, and all reduced the risk to the same number of properties in the floodplain (all of them). For a given levee height, the alignments were equivalent in their reduction in flood risk and thus their total economic impact. They did, however, differ somewhat in their environmental impacts, aesthetics, and cost. A description of the array of levee alignments can be found in the Chapter 3 of the Integrated Feasibility Report and Environmental Impact Statement. Because the NED option is that which has the greatest net economic benefits (benefits minus costs), the NED structural option would be, by default, a levee of some height built along the cheapest alignment. Thus, the cheapest (most efficient) alignment was carried forward and analyzed at multiple heights in order to determine the levee height that maximized net economic benefits.

The final NED analysis evaluates twelve flood risk management project options – the No Action Plan, ten structural options, and a non-structural option. The non-structural option involves the gradual but permanent evacuation of the floodplain and relocation of residents and businesses, and the construction of a ring levee and other features to protect the SJ/SC WPCP. Preliminary estimates of the cost of the non-structural plan were in excess of $425 million. A value- engineering review during the study process recommended that, in the spirit of USACE planning modernization[12], because of the extremely high cost of implementation no detailed analysis be conducted and no additional resources were devoted to considering this option. While this option was effectively screened out, this section will include a description of the limited analysis done to develop a cost estimate for implementation.

All of the structural options involve the construction of levees bay-ward of the community of Alviso and the adjacent WPCP. For the reason described above, the options differ only in their height, but not their alignment; the least cost alignment was used for all the levee options. This least cost alignment is depicted in Figure 22 (Least Cost FRM Levee Alignment), with the levee shown in red. Levees between 10’ (NAVD 88) and 15’ were analyzed in half-foot increments. A 15.2’ levee height was included as a local preference that corresponds to an elevation two feet above the mean 1% ACE water surface elevation at year 2067 (the end of the period of analysis). The results of the analysis of this levee are discussed in Section 8 (Results for the NED/NER and Locally- Preferred Plans).

[12] http://planning.usace.army.mil/toolbox/library/misc/StrongPoint%20-%20Civil%20Works%20Transformation%20-%20Planning%205%20APR%2012.pdf

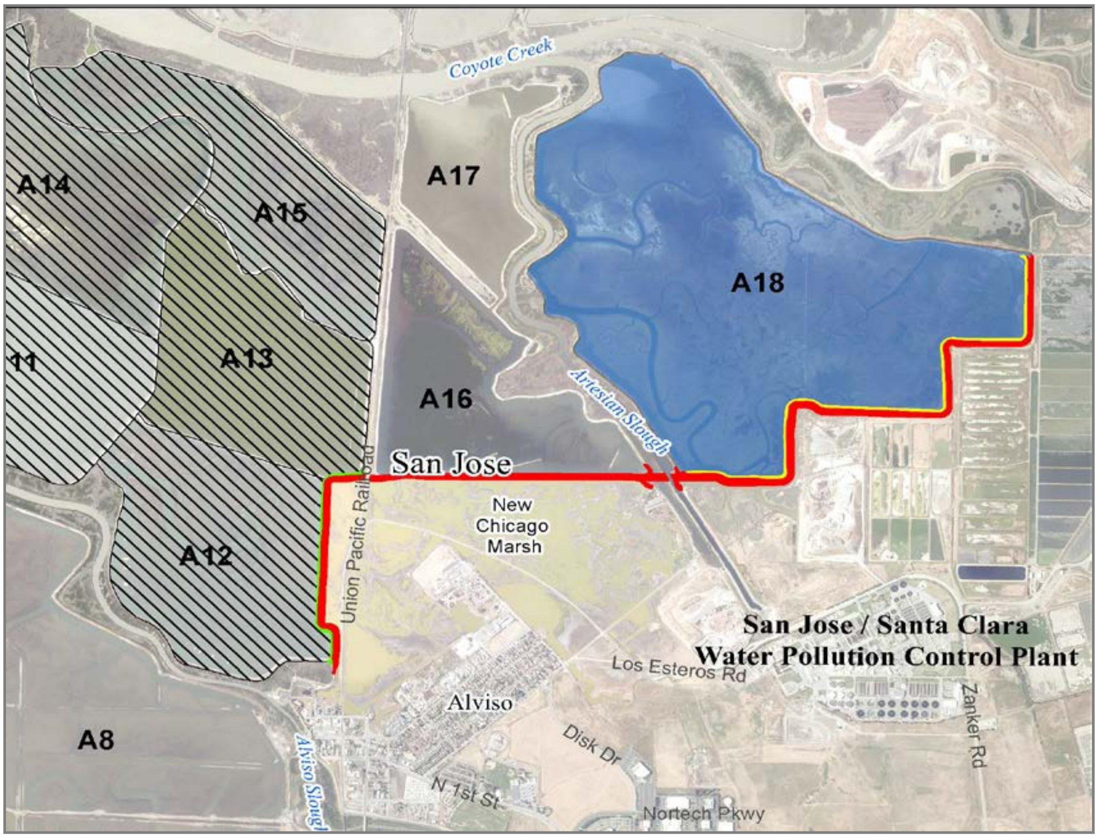


Figure 22: Least Cost FRM Levee Alignment

3.1. Non-Structural Option

Given the probability of future flooding under all sea level change scenarios, in the absence of a structural plan that keeps water away from assets and people in the study area, the only non-structural measures that are thought to be potentially feasible within a stand-alone non-structural option are those that significantly change the stage-damage relationship in the floodplain while not precluding restoration opportunities in the study area. Measures such as wet or dry flood-proofing and structure raises would result in a high residual risk to structures, and to health and human safety. Effective wet or dry flood-proofing would be impossible given the high expected future frequency of deep flooding in the area. Structure raises would be more effective at reducing the risk to structures in the study area, but would not significantly reduce the risk to health and human safety, nor to any assets and structures that cannot reasonably be elevated.

For the above reasons, it was determined that, given the characteristics of the study area and of the flood risk, the only effective non-structural alternative would include a permanent evacuation of the community of Alviso and the adjacent properties, and the construction of a ring levee around the SJ/SC WPCP.

In accordance with USACE planning policies and procedures, information developed by real estate personnel during the feasibility study was used to estimate the cost of this relocation alternative. An analysis was completed by the USACE San Francisco and Sacramento Districts Real Estate Sections in April 2012. The results of the analysis are briefly described below.

The determination of which structures would be relocated as part of the non-structural alternative is not straight forward. There is no policy that can be cited that would require that all structures within a certain return period floodplain (5-year, 10-year, etc.) be relocated. One important consideration though is that in order to be able to compare alternatives, the assumptions made for the analysis of the non-structural alternative must be consistent with those made for the structural alternatives analysis.

The flood damage reduction benefits of this non-structural alternative are equivalent to the damages reduced from relocation. Since relocating a property out of the floodplain reduces its flood risk to zero, the damages reduced for this alternative will be the sum of the without-project flood risk to those structures identified for relocation. After relocating these properties there would be some small amount of residual risk because not all properties in the floodplain are assumed to be removed. However, the damage to these properties constitutes no more than five percent of the estimated flood damage in the study area, and for this reason the benefits will be simply assumed to be equivalent to the total without-project damage.

After reviewing the cost it became clear that, no matter how the relocations were assumed to be phased or timed, this alternative would – from an NED perspective – not compete well against the structural alternatives. The total cost to acquire comparable properties in a flood-free area was estimated by USACE Real Estate to be $391 million. Adding to that property acquisition cost is the cost of a ring levee around the WPCP, and the Federal and non-Federal administrative costs of the real estate work. Table 9 (Non-Structural FRM Option Costs) below shows the estimated cost of implementing the non-structural alternative. The cost of structure demolition, which has historically been around $12k per residential structure for other projects, and other potential associated costs (cleanup, mitigation, etc.) have not been estimated in detail and are thus not included in the Table 9.

Table 9: Non-Structural FRM Option Costs

Cost Type	Cost (1,000s)
Flood-Free Property Acquisition Cost	$390,740
Fed & Non-Fed Real Estate Administration	$8,200
Ring Levee Construction (Incl. RE)	$25,000
Fed & Non-Fed Real Estate Administration	$1,500
Total	$425,440

4. FRM Option NED Analysis

4.1. Identification of the FRM NED Option

All of the options significantly reduce flood risk in the study area. Depending on the SLC scenario and levee height, the reduction in equivalent annual flood damage is between $11M and $40M. The NED levee height (that with the greatest net economic benefits) is 12.5’ under the USACE Low and Intermediate SLC scenarios, and 13.5’ under the USACE High SLC scenario. Table 10 through Table 12 summarize the results of the benefit-cost analysis completed for the comparison of the FRM options and the identification of the NED options. As Tables 10 through 12 show, there is very little difference in the net benefits of several of the levee options evaluated under each of the SLC scenarios. As an illustration of this point, under the USACE High SLC scenario, compared to the NED option, there is less than a 1% difference in net benefits for the next smaller and next larger levee heights. A similar story can be told for results under the USACE Low and Intermediate SLC scenarios.

The costs shown below differ slightly from the costs shown later in Section 8 (Results for the NED/NER and Locally Preferred Plans) for the final description of the NED options under each of the SLC scenarios as well as the locally-preferred FRM option (LPP). The NED and LPP levee option costs were updated to FY 15 price levels and subjected to a cost and schedule risk analysis as well as additional rounds of review. Performing a cost and schedule risk analysis on the entire array of alternatives would not be expected to change the identification of the NED option under each SLC scenario.

Table 10: Results of FRM Option NED Analysis – USACE Low SLC Scenario

Without-Project Equivalent Annual Flood Damage (1,000s)										
Structure & Content Damage	$11,478									
Relocation Cost	$6,691									
Total	$18,170									
With-Project Equivalent Annual Damages & Damages Reduced (1,000s)										
	No Action	**11' Levee**	**11.5' Levee**	**12' Levee**	**12.5' Levee**	**13' Levee**	**13.5' Levee**	**14' Levee**	**15' Levee**	**Non-Structural**
With-Project Avg Annual Flood Damage	$18,170	$2,418	$1,123	$84	$17	$0	$0	$0	$0	$0
Annual Damages Reduced	$0	$15,752	$17,047	$18,086	$18,153	$18,170	$18,170	$18,170	$18,170	$18,170
Project Costs (1,000s)										
Project First Cost	$0	$58,186	$59,761	$61,336	$62,486	$63,636	$65,536	$67,436	$71,536	$425,000
Interest During Construction	$0	$3,021	$3,102	$3,184	$3,244	$3,304	$3,402	$3,501	$3,714	$0
Total Investment Costs	$0	$61,207	$62,863	$64,520	$65,730	$66,940	$68,938	$70,937	$75,250	$425,000
Capital Recovery Factor	0.0426	0.0426	0.0426	0.0426	0.0426	0.0426	0.0426	0.0426	0.0426	0.0426
Average Annual Costs	$0	$2,607	$2,678	$2,749	$2,800	$2,852	$2,937	$3,022	$3,206	$18,105
Annual O&M Costs	$0	$387	$387	$387	$387	$387	$387	$387	$387	$0
Total Average Annual Costs	$0	$2,994	$3,065	$3,136	$3,187	$3,239	$3,324	$3,409	$3,593	$18,105
Results										
Annual Net Benefits	**$0**	**$12,758**	**$13,982**	**$14,951**	**$14,966**	**$14,931**	**$14,846**	**$14,761**	**$14,577**	**$65**
Benefit-to-Cost Ratio	**N/A**	**5.26**	**5.56**	**5.77**	**5.70**	**5.61**	**5.47**	**5.33**	**5.06**	**1.00**

Table 11: Results of FRM Option NED Analysis – USACE Intermediate SLC Scenario

Without-Project Equivalent Annual Flood Damage (1,000s)										
Structure & Content Damage	$15,391									
Relocation Cost	$7,153									
Total	$22,545									
With-Project Equivalent Annual Damages & Damages Reduced (1,000s)										
	No Action	**11' Levee**	**11.5' Levee**	**12' Levee**	**12.5' Levee**	**13' Levee**	**13.5' Levee**	**14' Levee**	**15' Levee**	**Non-Structural**
With-Project Avg Annual Flood Damage	$22,545	$3,894	$1,534	$131	$21	$1	$0	$0	$0	$0
Annual Damages Reduced	$0	$18,650	$21,011	$22,414	$22,524	$22,544	$22,545	$22,545	$22,545	$22,545
Project Costs (1,000s)										
Project Cost	$0	$58,186	$59,761	$61,336	$62,486	$63,636	$65,536	$67,436	$71,536	$425,000
Interest During Construction	$0	$3,021	$3,102	$3,184	$3,244	$3,304	$3,402	$3,501	$3,714	$0
Total Investment Costs	$0	$61,207	$62,863	$64,520	$65,730	$66,940	$68,938	$70,937	$75,250	$425,000
Capital Recovery Factor (CRF)	0.0426	0.0426	0.0426	0.0426	0.0426	0.0426	0.0426	0.0426	0.0426	0.0426
Average Annual Costs	$0	$2,607	$2,678	$2,749	$2,800	$2,852	$2,937	$3,022	$3,206	$18,105
Annual O&M Costs	$0	$387	$387	$387	$387	$387	$387	$387	$387	$0
Total Average Annual Costs	$0	$2,994	$3,065	$3,136	$3,187	$3,239	$3,324	$3,409	$3,593	$18,105
Results										
Annual Net Benefits	**$0**	**$15,656**	**$17,946**	**$19,278**	**$19,337**	**$19,305**	**$19,221**	**$19,136**	**$18,952**	**$4,440**
Benefit-to-Cost Ratio	**N/A**	**6.23**	**6.86**	**7.15**	**7.07**	**6.96**	**6.78**	**6.61**	**6.28**	**1.25**

Table 12: Results of FRM Option NED Analysis, USACE High SLC Scenario

Without-Project Equivalent Annual Flood Damage (1,000s)										
Structure & Content Damage	$31,902									
Relocation Cost	$8,293									
Total	$40,195									
With-Project Equivalent Annual Damages & Damages Reduced (1,000s)										
	No Action	**11' Levee**	**11.5' Levee**	**12' Levee**	**12.5' Levee**	**13' Levee**	**13.5' Levee**	**14' Levee**	**15' Levee**	**Non-Structural**
With-Project Avg Annual Flood Damage	$40,195	$29,154	$14,490	$5,071	$1,575	$419	$92	$16	$0	$0
Annual Damages Reduced	$0	$11,040	$25,704	$35,123	$38,619	$39,776	$40,103	$40,178	$40,195	$40,195
Project Costs (1,000s)										
Project Cost	$0	$58,186	$59,761	$61,336	$62,486	$63,636	$65,536	$67,436	$71,536	$425,000
Interest During Construction	$0	$3,021	$3,102	$3,184	$3,244	$3,304	$3,402	$3,501	$3,942	$0
Total Investment Costs	$0	$61,207	$62,863	$64,520	$65,730	$66,940	$68,938	$70,937	$75,478	$425,000
Capital Recovery Factor (CRF)	0.0426	0.0426	0.0426	0.0426	0.0426	0.0426	0.0426	0.0426	0.0426	0.0426
Average Annual Costs	$0	$2,607	$2,678	$2,749	$2,800	$2,852	$2,937	$3,022	$3,215	$18,105
Annual O&M Costs	$0	$387	$387	$387	$387	$387	$387	$387	$387	$0
Total Average Annual Costs	$0	$2,994	$3,065	$3,136	$3,187	$3,239	$3,324	$3,409	$3,602	$18,105
Results										
Annual Net Benefits	**$0**	**$8,046**	**$22,639**	**$31,988**	**$35,432**	**$36,537**	**$36,779**	**$36,770**	**$36,592**	**$22,090**
Benefit-to-Cost Ratio	**N/A**	**3.69**	**8.39**	**11.20**	**12.12**	**12.28**	**12.07**	**11.79**	**11.16**	**2.22**

4.2. NED Option Project Performance Comparison

Compared to the without-project future condition, all of the levee options significantly reduce the risk of flooding over the period of analysis. Table 13 (HEC-FDA Project Performance Statistics in 2067) below displays the project performance statistics for the No Action option and two FRM levee options in the year 2067. The Mean Annual Exceedance Probability is the likelihood of flooding in any given year, although in this case because of rising sea level this value reflects a snapshot in time at the year 2067. The Long-Term Risk (30 Years) represents the likelihood over a 30-year period that a flood event will occur. Thirty years was chosen to display because that is the duration of a typical home mortgage loan and is therefore a time interval would be familiar to members of the public during flood risk communication efforts. The Conditional Non-Exceedance Probability Event is the likelihood that the levee will not be exceeded (overtopped) by storm events of various sizes and recurrence intervals. In this case the 10%, 2%, 1%, and 0.2% ACE events are displayed. Note that these statistics are a function of the engineering, rather than economic inputs to the HEC-FDA model.

For illustration's sake, the results table shows that, depending on the SLC scenario, a 13.5' levee at the year 2067 has between a 0.02% and 0.48% chance of being overtopped each year (mean annual exceedance probability). At the 2067 sea level, over a thirty year period there is between a 0.65% chance and 13% chance of a damaging flood event occurring (Long-Term Risk (30 Years)). Finally, there is between a 99% and 88% chance of that levee containing the 1% ACE event in the year 2067 (Conditional Non-Exceedance Probability by Event).

Table 13: HEC-FDA Project Performance Statistics in 2067[13]

SLC Scenario	FRM Option	Mean Annual Exceedence Probability	Long-Term Risk (30 Years)	Conditional Non-Exceedence Probability by Event			
				10%	2%	1%	0.20%
Low	No Action	39.5%	99.9%	36.9%	24.7%	16.2%	3.9%
	12.5' Levee	0.08%	2.6%	99.9%	99.9%	99.9%	94.9%
	13.5' Levee	0.02%	0.7%	99.9%	99.9%	99.9%	99.9%
Intermediate	No Action	53.2%	99.9%	29.6%	7.3%	5.4%	2.5%
	12.5' Levee	0.08%	2.0%	99.9%	99.9%	99.9%	92.6%
	13.5' Levee	0.02%	0.6%	99.9%	99.9%	99.9%	99.9%
High	No Action	94.9%	99.9%	0.3%	<.01%	<.01%	<.01%
	12.5' Levee	8.51%	93.0%	66.7%	3.2%	0.7%	0.0%
	13.5' Levee	0.48%	13.4%	99.9%	98.3%	88.2%	33.5%

4.3. Residual Risk

Residual risk is the risk that remains after the project has been implemented. Both the 12.5' and 13.5' levee heights would in general have very low residual risk at the time of construction and for many years afterwards. However, the residual risk will increase as sea-level rises over time under any of the three USACE SLC scenarios, and significant differences between the residual risk of the two levee heights emerge later in the period of analysis.

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[13] Note that low scenario project performance results show slightly greater residual risk for the two levee scales than under the intermediate scenario. This is due to slightly greater uncertainty in stages for very low probability events under the low scenario, and only under such low probability events is there any possibility of stages that exceed these levee heights. Regardless, the project performance statistics are similar for the two scenarios, e.g., both showing a 99.9% level of assurance for the 1% ACE event.

Equivalent annual damage remaining is one measure of residual flood risk. The equivalent annual damage at 2017 is zero for either of the levee heights. This does not mean that residual flood risk is zero, but the likelihood of flood damage is so low as to be negligible. Under the USACE Low and Intermediate SLC scenarios, the equivalent annual damage at the end of the period of analysis is still very low. However, under the USACE High scenario, the 12.5’ levee has significantly more residual risk than higher levees. For example, according to the HEC-FDA modeling, in 2047 the equivalent annual damage for the 12.5’ levee is nearly $1M, and increases to more than $20M by 2067. In contrast, the equivalent annual damage for the 13.5’ levee does not reach $1M until 2067. Levees 15’ or higher would have an extremely low likelihood of being overtopped over the period of analysis under even the USACE High SLC scenario. The degree of residual risk beyond the period of analysis obviously depends on the rate of future sea level change.

The equivalent annual damage calculations referenced above are based on overtopping events and assume no other flooding mechanism such as a levee breach. While no levee can be said to eliminate all risk of failure below the top of levee elevation, if well maintained the likelihood of structural failure for any of the three levees is estimated to be very low. The consequences of a levee breach during a storm event would be significant, but the likelihood is considered extremely low. As always, residual risk can be further reduced with effective floodplain management and flood warning and evacuation plans.

4.4. Comparison of NED Levee Options

Table 14 (Summary of NED Analysis Results) compares the primary results for the two levee heights showing the greatest net benefits across the three USACE SLC scenarios – 12.5’ and 13.5’. From a net benefits and BCR perspective the two levees are very similar under each SLC scenario. Since EC 1165-2-212 doesn’t assign probabilities to the three SLC scenarios, it is not possible to identify the overall best plan by weighting the results for each levee option under the three SLC scenarios. However, it should be noted that when either summing or averaging the net benefits of each levee under the three scenarios, the 13.5’ option comes out slightly ahead of the 12.5’ option.

The real difference between the two options emerges under the USACE High SLC scenario in terms of residual risk and average annual exceedance probability. According to the results described in the Coastal Engineering Summary (Appendix E), at 2067 the 1% ACE water surface elevation is 13.2’, which would exceed the 12.5’ levee. According to the HEC-FDA modeling, the expected annual residual damage at 2067 would be approximately $21M, while the damage with a 13.5’ levee would be significantly less. There is an almost ten percent annual chance of coastal waters exceeding the 12.5’ levee at 2067, compared to less than a 1% chance with a 13.5’ levee.

Table 14: Summary of NED Analysis Results

SLC Scenario	FRM Option	Total Equivalent Annual Benefits	Net Benefits	BCR	Residual Equivalent Annual Damage	Residual Annual Damage (2067)	Average Annual Exceedence Probability (2067)
Low	12.5' Levee	$18,200	$15,000	5.7	$17	$244	0.08%
	13.5' Levee	$18,200	$14,800	5.5	$3	$60	0.02%
Intermediate	12.5' Levee	$22,500	$19,300	7.1	$21	$300	0.08%
	13.5' Levee	$22,500	$19,200	6.8	$3	$60	0.02%
High	12.5' Levee	$38,600	$35,400	12.1	$1,600	$21,000	8.51%
	13.5' Levee	$40,100	$36,800	12.1	$92	$1,500	0.48%

Dollars in thousands

4.5. Sensitivity Analysis: Economic Justification and Levee Failure Probability

The results presented above show strong economic justification for the alternatives evaluated. The strong justification is in large part the result of the finding that there is currently a high annual likelihood of flooding in the study area. The most uncertain of the inputs to the estimation of the likelihood of flooding in the study area is the likelihood of failure of the outer dike, which is incorporated in the FDA model as the without-project levee failure function. Because of the uncertainty, a sensitivity analysis was conducted to determine how changes to the levee failure function affect project economic justification. The results of this sensitivity analysis are presented in Addendum B at the end of this appendix. These results show that if the without project levee failure function is modified to reflect a zero percent chance of failure up to an elevation of 10 feet, without project damages, without project performance statistics and with project benefits are all substantially reduced. However, the proposed alternatives still show strong economic justification. See Addendum B fur further details.

5. Cost-Effectiveness & Incremental Cost Analysis (CE/ICA) of Restoration Plans

This section describes the result of the cost-effectiveness and incremental cost analysis (CE/ICA) that was conducted in order to provide economic metrics with which to compare the various ecosystem restoration options. This process helps to identify the National Ecosystem Restoration (NER) option, which by definition is one of the cost-effective plans, and is typically chosen be chosen from the suite of what are called "Best Buy" plans.

5.1. Overview of Evaluation Procedures

Ecosystem restoration projects incur the same types of financial costs as a traditional USACE project, such as preconstruction engineering and design, real estate, construction, and ongoing operation, maintenance and rehabilitation. Unlike for a traditional project, however, benefits arising from an ecosystem restoration project are not monetized. According to USACE guidance:

> *"Contributions to national ecosystem restoration (NER outputs) are increases in the net quantity and/or quality of desired ecosystem resources. Measurement of NER is based on changes in ecological resource quality as a function of improvement in habitat quality and/or quantity and expressed quantitatively in physical units or indexes (but not monetary units)."*[14]

A benefit-cost analysis – a comparison of net benefits and costs of each plan (or option, in the case of this study) – cannot be performed during ecosystem restoration studies because the costs and benefits are expressed in different units. While a benefit-cost analysis is considered ideal in USACE plan evaluation, cost effectiveness and incremental cost analyses (CE/ICA) provide essential information for decision making in its absence.

In order to determine the contribution of a particular project to the Environmental Quality account, it is necessary to characterize and rank the cost effectiveness of the various options that are part of a particular study. That is, each option can generally be a combination of measures, the sum of which has a particular level of habitat value and a particular monetary cost associated with it. A cost-effectiveness analysis is

[14] ER 1105-2-100

simply a way of finding, for a given level of habitat output, those combinations of restoration measures that provide the best value.

The first step is to identify options that are inefficient in production, and remove them from consideration; this is the cost-effectiveness analysis. An option is defined as inefficient when another option provides the same or greater level of output at less cost. The incremental cost analysis then compares the cost of increasing output between each option. This process helps decision-makers understand cost changes as output levels are increased.

Table 15 (Costs & Outputs of Restoration Measures) shows the inputs to the CE/ICA. For each measure, the table shows the monetary cost and the environmental output. The environmental output results come from the CHAP model. More on this model can be found in Appendix J of the Integrated Feasibility Report and Environmental Impact Statement/Report (Environmental Benefits Analysis (CHAP) Summary and Model Outputs).

There are four pond groupings that are being considered as part of the restoration effort. These groupings are called A12, A9-A11, A13-A15, and A18. Table 15 below shows the cost and restoration output associated with restoration of each of the groupings with two different scales or features for each group. For each pond group, the two options are basic pond restoration, and basic pond restoration with a 30:1 slope ecotone. Two additional options were also considered for each pond: accelerated restoration, and a 100:1 slope ecotone. The CHAP model was generally unable to demonstrate that additional costs associated with accelerating restoration or adding an ecotone would result in additional environmental outputs. Although this was also true for the 30:1 slope ecotone, this option was carried forward for detailed analysis in the CE/ICA as it was identified as important to the non-federal sponsors and potentially part of a locally preferred plan.

Table 15: Costs & Outputs of Restoration Measures (FY 14 price levels)[15] [16]

Restoration Measure	Total Cost	Output (CHAP)	AAC 3.375%	AAC/AAHU
No Action	$0	N/A		
Pond A12 basic restoration	$3,927,540	6,171	$163,689	$27
Pond A12 basic restoration w/ ecotone (30:1)	$14,670,402	6,115	$611,422	$100
Ponds A9 - A11 basic restoration	$11,514,519	15,356	$479,894	$31
Ponds A13 - A15 basic restoration	$10,698,311	12,403	$445,876	$36
Ponds A13 - A15 basioc restoration w/ecotone (30:1) *	$12,833,776	12,400	$534,877	$43
Pond A18 basic restoration	$8,338,038	14,577	$347,507	$24
Pond A18 basic restoration w/ecotone (30:1)	$31,114,203	14,437	$1,296,755	$90

In order to perform the analysis it is necessary to describe which measures are combinable, not combinable, dependent, and independent. Following extensive discussions with the PDT, the following logic was applied in the IWR Plan CE/ICA model:

[15] Measures called “phased restoration” are also called “basic restoration” or “basic phased restoration” in the feasibility report.

[16] The cost of the 30:1 ecotone was revised significantly downward based on changed assumptions regarding the cost of fill material. As described in Section 10, the ecotone is a feature of the locally-preferred plan. The CE/ICA analysis in this section reflects the updated costs at FY 14 price levels for the restoration features.

- A18 could be implemented independently but is combinable with any of the other measures
- A12 could be implemented independently but is combinable with any of the other measures
- A9-A11 is dependent on A12, meaning it would not be implemented without A12
- A13-A15 is dependent on A9-A11 and A12, meaning that it would not be implemented without the implementation of those two pond groupings

Given the relationships and constraints specified above, including the No Action Plan there are 27 possible combinations of measures – therefore, there are 27 possible options.

As noted, the CHAP model was generally unable to demonstrate that additional costs associated with accelerating restoration or adding an ecotone would result in additional environmental outputs. In fact, for Pond A12, Ponds A13-A15, and Pond A18, the model shows that additional cost and additional features result in the same or fewer average annual outputs. This model result is at odds with what the PDT believes would be the real-world result. For example, according to the PDT's environmental planners, by implementing the restoration more quickly, an accelerated phased restoration should result in a greater average annual restoration value than a slower phased restoration (i.e., basic phased restoration). Like all models, the CHAP model is an imperfect representation of the real world, and it is not sophisticated enough to demonstrate and quantify this difference.

5.2. Cost-Effectiveness Analysis

Table 16 (CE/ICA Step 1 – Identification of Inefficient Combinations) shows the list of combinations of all measures in increasing order of output. Inefficient combinations are those that for a given level of output can be produced more cheaply. Since none of the combinations have the same exact output, none of the alternatives are screened out based on this criterion.

Figure 23 (Plot of All 27 Plans - IWR Plan Results) is a scatterplot of the restoration measure combinations as shown in the program IWR Planning Suite. The costs shown in the figures and tables of the cost-effectiveness and incremental cost analysis are in average annual terms.

Table 16: CE/ICA Step 1 – Identification of Inefficient Combinations

Plan	Output (HUs)	AAC	Inefficient?
(A12 with Ecotone)	6,115	$611,422	No
A12	6,171	$163,689	No
(A18 with Ecotone)	14,437	$1,296,755	No
A18	14,577	$347,507	No
(A18 with Ecotone) + (A12 with Ecotone)	20,552	$1,908,177	No
(A18 with Ecotone) + A12	20,608	$1,460,444	No
A18 + (A12 with Ecotone)	20,692	$958,929	No
A18 + A12	20,748	$511,196	No
(A12 with Ecotone) + (A9-A11)	21,471	$1,091,316	No
A12 + (A9-A11)	21,527	$643,583	No
(A12 + Ecotone) + (A9-A11) + (A13+A15 with Ecotone)	33,871	$1,626,192	No
(A12 + Ecotone) + (A9-A11) + (A13-A15)	33,874	$1,537,192	No
A12 + (A9-A11) + (A13-A15 with Ecotone)	33,927	$1,178,459	No
A12 + (A9-A11) + (A13-A15)	33,931	$1,089,459	No
(A18 with Ecotone) + (A12 with Ecotone) + (A9-A11)	35,908	$2,388,070	No
(A18 with Ecotone) + A12 + (A9-A11)	35,964	$1,940,337	No
A18 + (A12 with Ecotone) + (A9-A11)	36,048	$1,438,822	No
A18 + A12 + (A9-A11)	36,104	$991,089	No
(A18 with Ecotone) + (A12 + Ecotone) + (A9-A11) + (A13+A15 with Ecotone)	48,308	$2,922,947	No
(A18 with Ecotone) + (A12 + Ecotone) + (A9-A11) + (A13-A15)	48,311	$2,833,947	No
(A18 with Ecotone) + A12 + (A9-A11) + (A13-A15 with Ecotone)	48,364	$2,475,214	No
(A18 with Ecotone) + A12 + (A9-A11) + (A13-A15)	48,368	$2,386,214	No
A18 + (A12 + Ecotone) + (A9-A11) + (A13+A15 with Ecotone)	48,448	$1,973,699	No
A18 + (A12 + Ecotone) + (A9-A11) + (A13-A15)	48,451	$1,884,699	No
A18 + A12 + (A9-A11) + (A13-A15 with Ecotone)	48,504	$1,525,966	No
A18 + A12 + (A9-A11) + (A13-A15)	48,508	$1,436,966	No

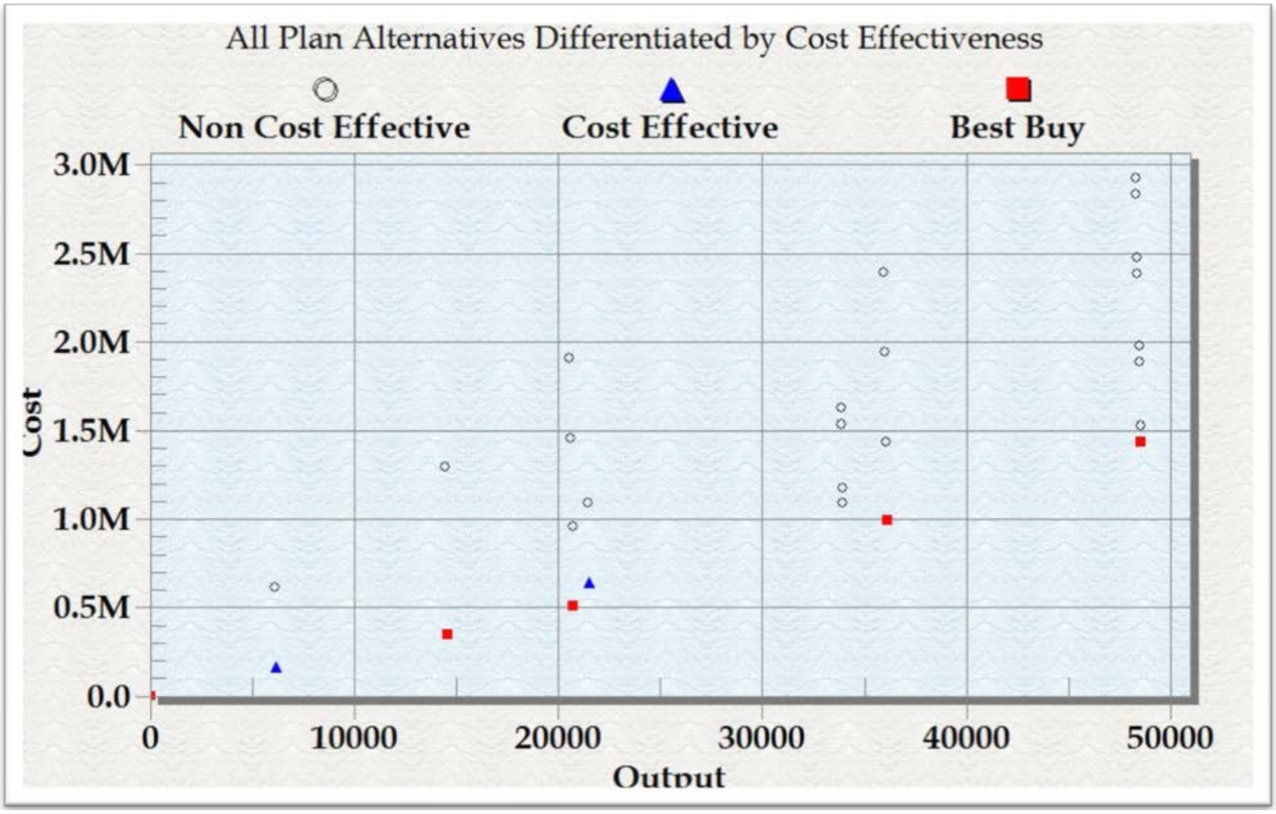

Figure 23: Plot of All 27 Plans - IWR Plan Results

After the inefficient combinations are screened, the remaining combinations are then screened for those that are termed "ineffective" in production. Ineffective plans are those where greater output can be produced at a lesser or equal cost. Table 17 (CE/ICA Step 2 - Identification of Ineffective Combinations) shows those plans that were screened out as a result of being designated as ineffective. The six plans highlighted in red are the remaining cost effective plans.

Table 17: CE/ICA Step 2 - Identification of Ineffective Combinations

Plan	Output (HUs)	AAC	Ineffective?
(A12 with Ecotone)	6,115	$611,422	Yes
A12	6,171	$163,689	No
(A18 with Ecotone)	14,437	$1,296,755	Yes
A18	14,577	$347,507	No
(A18 with Ecotone) + (A12 with Ecotone)	20,552	$1,908,177	Yes
(A18 with Ecotone) + A12	20,608	$1,460,444	Yes
A18 + (A12 with Ecotone)	20,692	$958,929	Yes
A18 + A12	20,748	$511,196	No
(A12 with Ecotone) + (A9-A11)	21,471	$1,091,316	Yes
A12 + (A9-A11)	21,527	$643,583	No
(A12 + Ecotone) + (A9-A11) + (A13+A15 with Ecotone)	33,871	$1,626,192	Yes
(A12 + Ecotone) + (A9-A11) + (A13-A15)	33,874	$1,537,192	Yes
A12 + (A9-A11) + (A13-A15 with Ecotone)	33,927	$1,178,459	Yes
A12 + (A9-A11) + (A13-A15)	33,931	$1,089,459	Yes
(A18 with Ecotone) + (A12 with Ecotone) + (A9-A11)	35,908	$2,388,070	Yes
(A18 with Ecotone) + A12 + (A9-A11)	35,964	$1,940,337	Yes
A18 + (A12 with Ecotone) + (A9-A11)	36,048	$1,438,822	Yes
A18 + A12 + (A9-A11)	36,104	$991,089	No
(A18 with Ecotone) + (A12 + Ecotone) + (A9-A11) + (A13+A15 with Ecotone)	48,308	$2,922,947	Yes
(A18 with Ecotone) + (A12 + Ecotone) + (A9-A11) + (A13-A15)	48,311	$2,833,947	Yes
(A18 with Ecotone) + A12 + (A9-A11) + (A13-A15 with Ecotone)	48,364	$2,475,214	Yes
(A18 with Ecotone) + A12 + (A9-A11) + (A13-A15)	48,368	$2,386,214	Yes
A18 + (A12 + Ecotone) + (A9-A11) + (A13+A15 with Ecotone)	48,448	$1,973,699	Yes
A18 + (A12 + Ecotone) + (A9-A11) + (A13-A15)	48,451	$1,884,699	Yes
A18 + A12 + (A9-A11) + (A13-A15 with Ecotone)	48,504	$1,525,966	Yes
A18 + A12 + (A9-A11) + (A13-A15)	48,508	$1,436,966	No

5.3. Incremental Cost Analysis

Table 18 (CE/ICA Step 3 – Identification of First Best Buy Plan) shows the six cost effective plans and their output, cost, and average annual cost per unit of output over the No Action Plan. The highlighted plan (A18) is identified as the first best buy plan because it has the lowest incremental cost per unit of output over the No Action Plan.

Table 18: CE/ICA Step 3 – Identification of First Best Buy Plan

Plan	Output (HUs)	AAC	AAC/AAHU
A12	6,171	$163,689	$26.52
A18	14,577	$347,507	$23.84
A18 + A12	20,748	$511,196	$24.64
A12 + (A9-A11)	21,527	$643,583	$29.90
A18 + A12 + (A9-A11)	36,104	$991,089	$27.45
A18 + A12 + (A9-A11) + (A13-A15)	48,508	$1,436,966	$29.62

The next Best Buy Plan is identified by calculating and comparing the incremental cost per unit of output over the last identified Best Buy Plan (A18). The green highlighted plan in Table 19 (CE/ICA Step 4 – Identification of Second Best Buy Plan), which consists of restoration of ponds A18 and A12, has the lowest incremental cost per unit as compared to the first Best Buy Plan.

Table 19: CE/ICA Step 4 – Identification of Second Best Buy Plan

Plan	Output (HUs)	AAC	Incr. HUs over Last Best Buy	Incr. AAC over Last Best Buy	Incr. AAC/HU over Last Bust Buy
A18	14,577	$347,507	14577	$347,507	$23.84
A18 + A12	20,748	$511,196	6171	$163,689	$26.52
A12 + (A9-A11)	48,311	$2,833,947	33734	$2,486,440	$73.71
A18 + A12 + (A9-A11)	36,104	$991,089	21527	$643,583	$29.90
A18 + A12 + (A9-A11) + (A13-A15)	48,508	$1,436,966	33931	$1,089,459	$32.11

Table 20 (Summary of Best Buy Plans, Annualized Values) shows the final results of the CE/ICA. As shown, there are four Best Buy plans. The table shows both costs and outputs in annual terms. Basic restoration of Pond A18 is the first Best Buy Plan, followed sequentially by the incremental addition of basic restoration of ponds A12, A9-11, and A13-15. Figure 24 shows the results of the CE/ICA analysis, identifying all of the cost effective and Best Buy Plans. In addition, it also shows the results for non-cost effective plans. Restoration of pond A18 with a 30:1 ecotone and restoration of all ponds with a 30:1 ecotone are also shown on the graph, as these plans are or interest as potential locally preferred plan options.

Table 20: Summary of Best Buy Plans, Annualized Values

Plan	Output (HUs)	AAC	Incr. HUs	Incr. AAC	Incr. AAC/AAHU
A18	14,577	$347,507	14,577	$347,507	$23.84
A18 + A12	20,748	$511,196	6,171	$163,689	$26.52
A18 + A12 + (A9-A11)	36,104	$991,089	15,356	$479,894	$31.25
A18 + A12 + (A9-A11) + (A13-A15)	48,508	$1,436,966	12,403	$445,876	$35.95

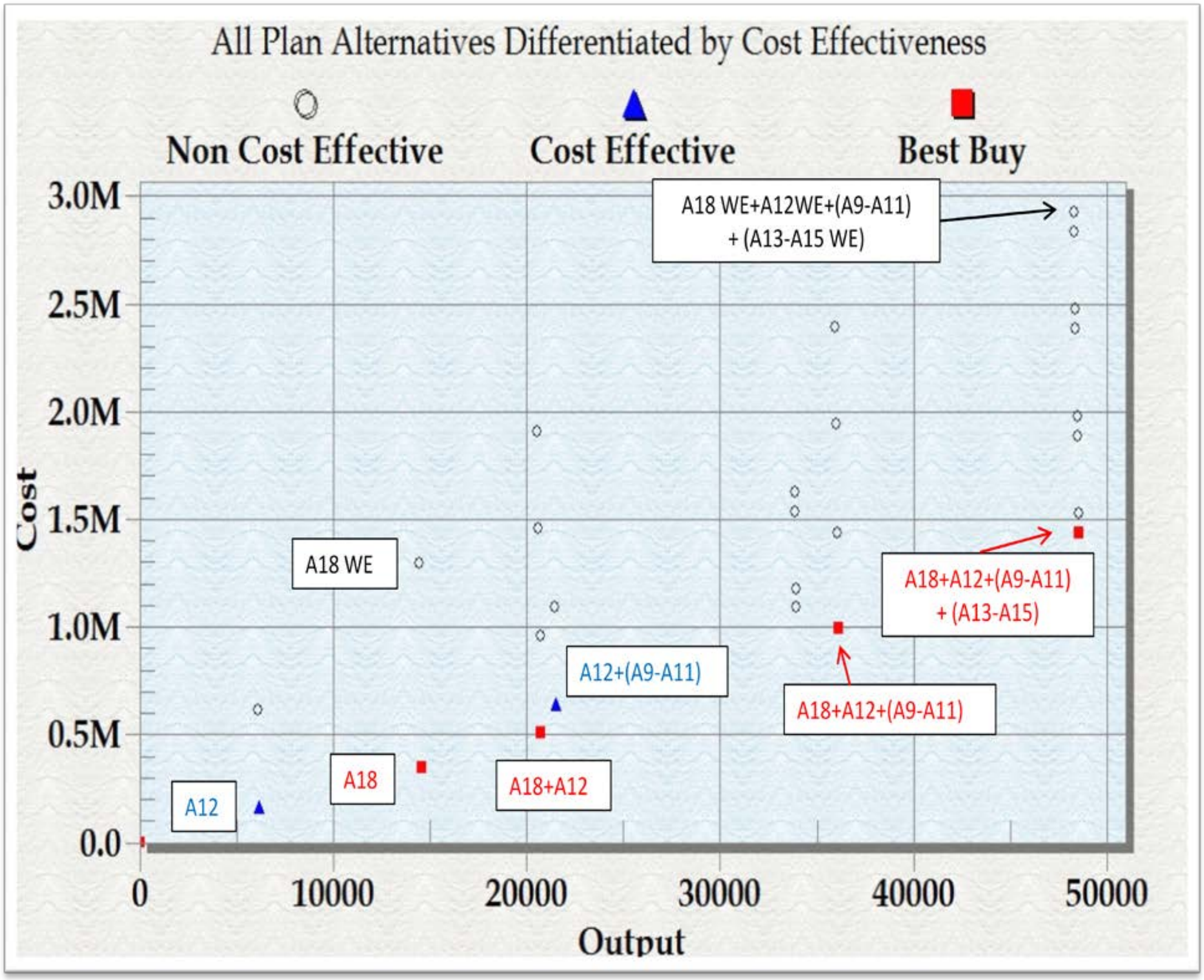

Figure 24: Plot of Cost Effective Plans - IWR Plan Model Results

Figure 25 shows a box plot of the incremental average annual cost per incremental gain in output for the four Best Buy Plans. Of particular note for this graph is that the increases in incremental costs per output are relatively minor for successively larger Best Buy Plans.

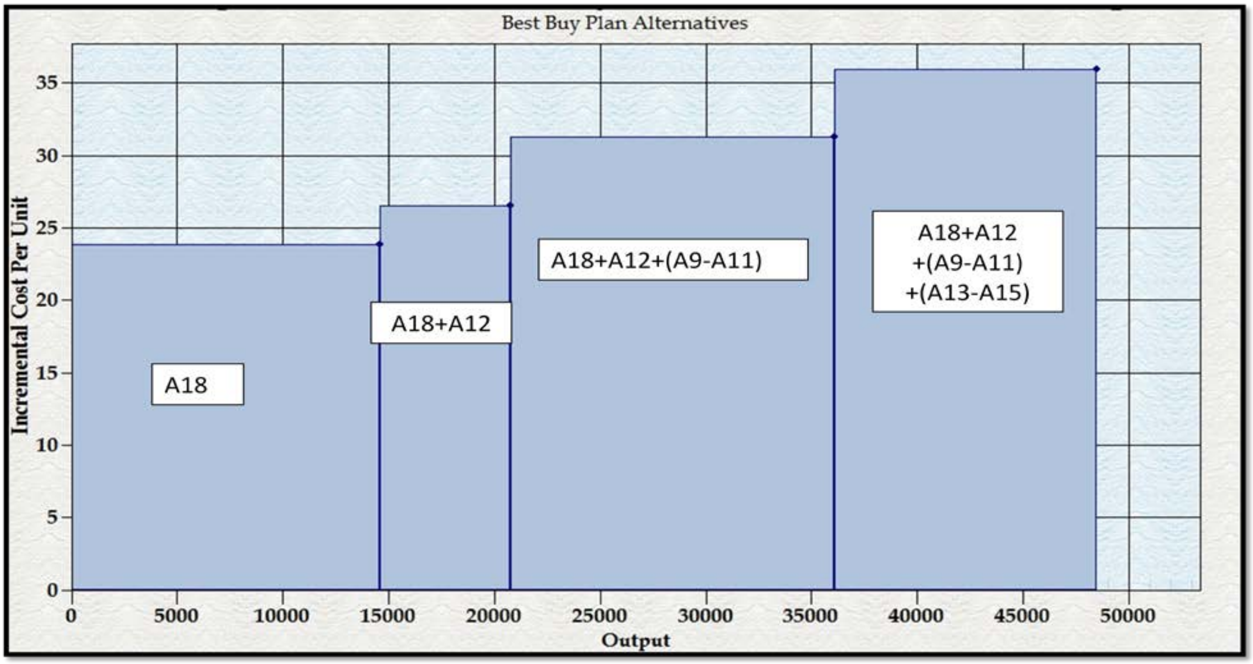

Figure 25: Plot of Cost Effective Plans - IWR Plan Model Results

5.4. Selection of the NER Plan

The analysis of the cost effectiveness and incremental cost of the restoration options shows that, not including the No Action option, there are six cost-effective options (also known as plans) and four best buy options or plans. As discussed in the study's main integrated document, the CHAP model was not able to show additional environmental outputs for restoration measures beyond the baseline restoration of basic restoration with a bench. In the case of the accelerated restoration measures that are considered, the lack of cost-effectiveness was due solely to the inability to obtain required predictions of future habitat conditions for this measure in GIS format under schedule and budget limitations. Thus, these conditions could not be input to the CHAP model to obtain results. Based on current ecological understandings, the environmental planners in the PDT expect that there would, in fact, be an increase in annual habitat outputs as a result of accelerating the restoration process within the pond groupings.

In the case of the ecotone (which is an area of transitional habitat between the bay and the FRM levees), CHAP found slightly lower annualized outputs when an ecotone was included in the restoration plan. This result was due to model characteristics. CHAP effectively places a higher value on local habitat conditions that result in more species being present. This is irrespective of landscape-scale ecological considerations which could lead to different judgments of the most desirable approach to restoration or to targeting of species of particular concern. Thus, loss of fish species in high marsh and upland habitats on the ecotone and their replacement by a small number of terrestrial species, including species listed under the Endangered Species Act, resulted in lower annualized outputs of ecosystem benefits. This aspect of the model results is at odds with current ecological understandings, and the environmental planners in the PDT expect that inclusion of an ecotone would provide a more complete and sustainable restoration plan. However, currently available and certified habitat models do not provide the degree of sophistication needed to demonstrate this.

According to USACE policy, the NER Plan should generally be derived from the final set of Best Buy solutions. Other solutions identified as non-cost effective in cost effectiveness analysis, as well as cost effective plans identified as relatively less efficient in production ("non-Best Buys") in incremental analysis, may, however, continue to be considered for selection.

The six cost-effective plans consist of combinations of basic restoration of the four pond groupings. The four best buy plans involve basic phased restoration of one or up to all four pond complexes. The selected NER option is the largest of the Best Buy Plans, which includes basic phased restoration of all of the pond complexes. As shown in the results of the CE/ICA analysis, the incremental cost per output for the largest plan is modest relative to the smaller Best Buy Plans (i.e., there is not a significant break in the incremental cost curve). The key question is whether these incremental costs are worth the incremental output. The largest Best Buy Plan has a large area of land and the inclusion of the additional pond complex which has important environmental outputs that, according to the California State Coastal Conservancy, are critical to the regional restoration effort. More on the importance of the pond complex to the regional environment can be found in the feasibility study integrated main report and environmental impact statement.

While the CE/ICA considered restoration options for all of the ponds, the USACE may only be able to participate in restoration of Pond A18 (the first Best Buy Plan). This is because implementation of restoration features on USFWS property is not consistent with USACE policies, and ponds A9-A15 are on land owned by the USFWS (more on this issue can be found in the Integrated Feasibility Report and Environmental Impact Statement). It is therefore important to note that if the CE/ICA considered just Pond A18 for restoration, No Action and Basic Restoration of A18 would be the only “best buy” options since all other options have fewer environmental outputs at a greater cost than basic restoration of this pond (see costs and output for Pond 18 alternatives in Table 15, as well as Table 16 (CE/ICA Step 1 – Identification of Inefficient Combinations).

6. Recreational Resources Analysis

6.1. Existing Recreational Resources

The study area currently contains approximately 21 miles of trails that are part of the larger regional Bay Trail[17]. The trails in this study area are of particular value because they are located in and around the Don Edwards San Francisco Bay National Wildlife Refuge (Refuge), the nation's first urban national wildlife refuge. The refuge, created in 1974, was largely the result of grassroots efforts by the local community to protect the San Francisco Bay ecosystem. According to the Refuge Manager, approximately 150,000 persons per year use the trail in the study area. The Refuge has a parking lot for several dozen cars as well as a visitor and education center. The trail and associated recreation features currently in the project area are depicted in Figure (Existing Location of the Bay Trail).

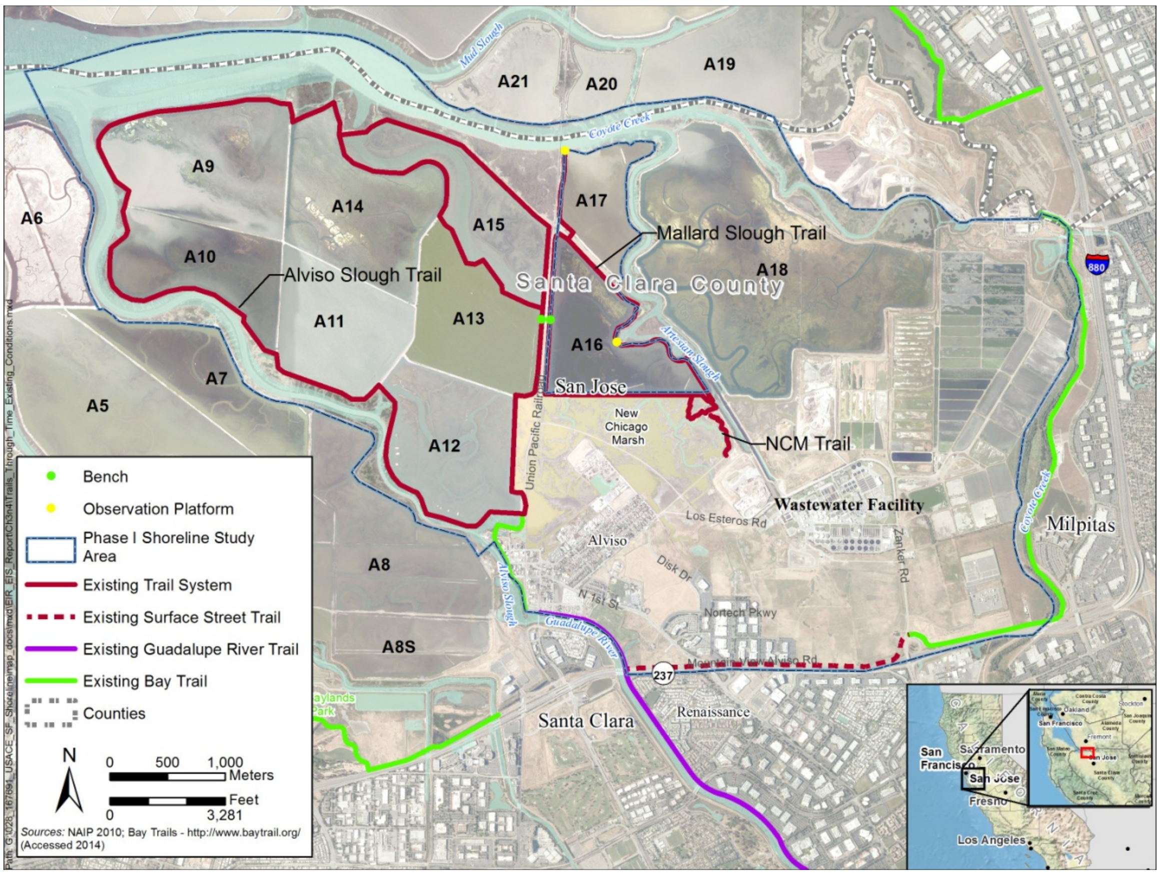

Figure 26: Existing Location of the Bay Trail

[17] According to www.baytrail.org, when complete, the Bay Trail will be a continuous 500-mile recreational corridor that will encircle the entire Bay Area, connecting communities to each other and to the Bay. It will link the shorelines of all nine counties in the Bay Area and 47 of its cities. To date, 310 miles of the Bay Trail, or more than 60 percent of its ultimate length, have been developed.

6.2. With-Project Impacts to Recreation Value

In order for a ecosystem restoration purpose of the project to be implemented, the existing approximately 11-mile loop trail located on top of levees surrounding Ponds A9 through A15 will have to be removed over time as these levees are breached to establish tidal connections between the ponds and the bay; the current estimate for completion of the pond breaches is 2030. In the absence of other measures taken, the removal of this loop trail would have an adverse impact on the recreation value in the study area. The Feasibility Report and Environmental Impact Statement describes recreation features intended to replace some or all of the recreation value lost by the breaching of the pond levees on USFWS lands. These compensatory features will either be implemented by the USFWS (consistent with standard USACE policy that the USACE will not implement actions on lands owned by another Federal agency if that agency has the authority to implement the actions in question) or by the USACE (pending implementation guidance for WRRDA 2014, Section 1025, which states that the USACE may implement actions on Federal lands if the non-Federal sponsor provided funds for the acquisition of those lands). The features include additional observation platforms and connecting to the levees along A18, which will improve the connectivity for bikers, runners, and walkers between the east and west sides of the salt pond complex. Figure 27 (Potential Final Bay Trail Configuration, ~ Year 2030) shows the project area recreation features upon completion of the pond levee breaches.

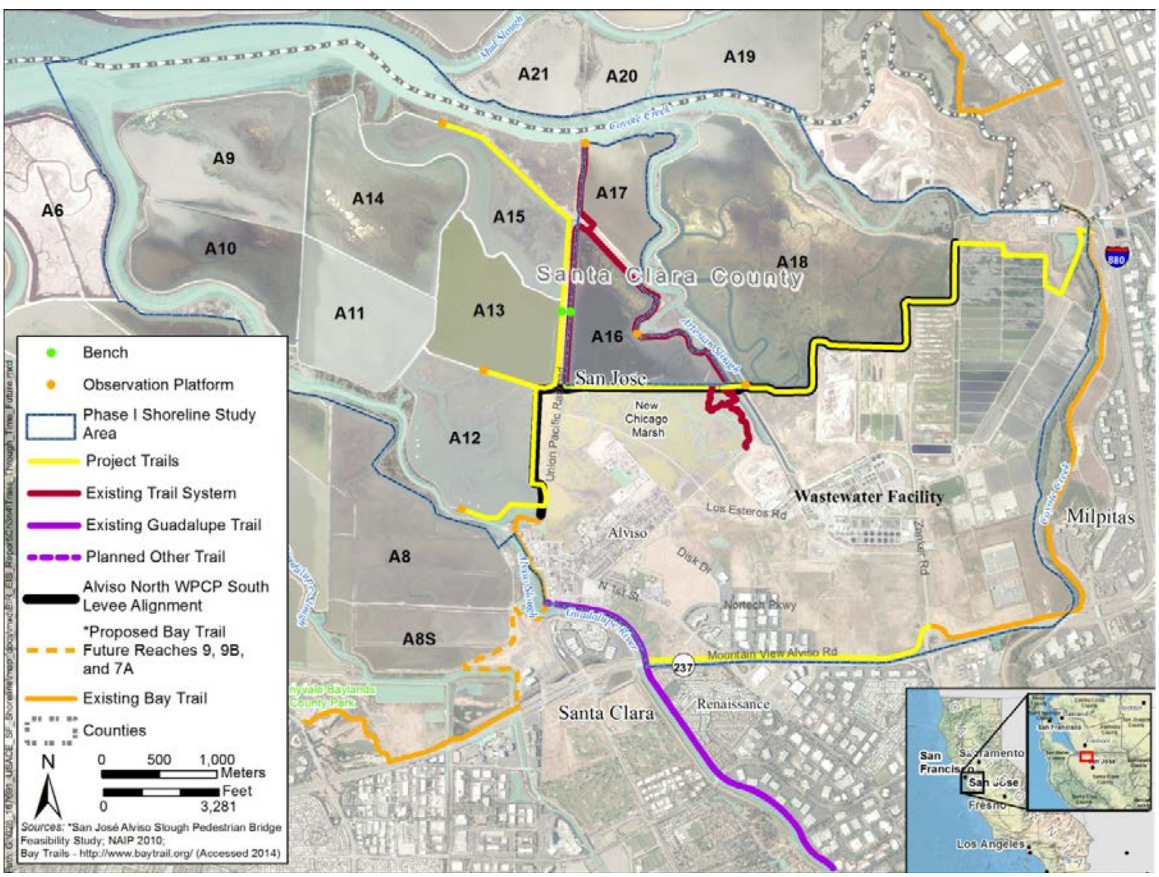

Figure 27: Potential Final Bay Trail Configuration, ~ Year 2030

The recreation features along Ponds A12, A13, A15, A16, and A17 are all located on land owned by the U.S. Fish and Wildlife Service (USFWS).

The levee along Pond A18 is owned by the City of San Jose, and recreation measures there can be part of a project implemented by the USACE in conjunction with the local project partners. The only recreation feature planned in this area is a bridge over Artesian Slough, which separates Ponds A16 and A17 from Pond A18 (see Figure 26 above). This bridge will connect the trail along the levee segments to the east and west of the slough. The bridge is estimated to cost $893K (includes construction management and design), which equates to an average annual value of approximately $38,100[18]. In order for the USACE to be able to share in the cost of this recreation feature, it must be shown to have net economic benefits. Whether or not the restoration of the ponds on USFWS land occurs should not significantly affect the recreation value calculated for the bridge because the increment of improvement in the recreation experience would be roughly the same as it is mostly attributable to improved accessibility – the increase in which should not change with or without a project implemented on USFWS land.

As stated above, officials at the USFWS estimate that the site gets 150,000 users per year on average. For recreation areas that are not classified as “high use” (high use is defined by the Planning Guidance Notebook as having greater than 750,000 annual visitors), USACE feasibility studies often use what is known as the Unit Day Value (UDV) method to value changes in recreational value associated with projects[19]. This method relies on expert or informed opinion and judgment to approximate the average willingness to pay of users of Federal or Federally-assisted recreation resources. The categories used to evaluate recreational resources are: Recreation Experience (number of activities), Availability of Opportunity (proximity of similar opportunities), Carrying Capacity (how additional use degrades the experience for the users), Accessibility, and Environmental (aesthetic qualities). The latest USACE Economic Guidance Memorandum (EGM 15-03) estimates the value of a general (non-specialized) recreation experience at between $3.91 and $11.87.

The pedestrian bridge over Artesian Slough (the only feature being analyzed here) will improve access to the site, and from a UDV perspective would increase the score of the Accessibility category. The UDV Method assigns up to 18 of the 100 total points to the Accessibility category. It is possible that the improved connectivity and accessibility will ultimately have the effect of increasing attendance at the site, but that effect is highly uncertain at this point and so has not been estimated. In general though, attendance is likely to increase over time simply due to population growth in the region. The improved access should at least marginally improve the carrying capacity of the site compared to a scenario without the bridge since the number of users would be spread over a longer distance of trail. Table 21 (UDV Points Assigned) below shows the points assigned for each of the criteria for both the without-bridge and with-bridge condition.

[18] Calculated by amortizing $1.6M over 50 years at an interest rate of 3.5%
[19] http://planning.usace.army.mil/toolbox/library/EGMs/EGM13-03.pdf

Table 21: UDV Points Assigned

Criteria	Key Variables	Range of Point Values	UDV Points Without Bridge	UDV Points With Bridge
Recreation Experience	Number & Type of Facilities	0-30	10	10
Availability of Opportunity	Number of Similar Opportunities Nearby	0-18	3	3
Carrying Capacity	Adequacy of Facilities for Activities	0-14	7	9
Accessibility	Ease of Access to and Within Site	0-18	13	18
Environmental	Esthetic Quality of Site	0-20	10	10
Total		**0-100**	**43**	**50**

Combining the UDV point data with the dollar values for general recreation results in an annual increase in recreational value of approximately $100,000. Table 22 (Recreation Value per User and per Year) shows the comparison of values without and with the bridge.

Table 22: Recreation Value per User and per Year

	UDV Points Assigned	Value per User	Annual Value
Without Bridge	43	$7.61	$1,142,100
With Bridge	50	$8.30	$1,245,000
Difference	7	$0.69	$102,900

The project first cost is estimated at approximately $908,700 at FY15 price levels. At an annualized cost of $38,500, the recreation feature is thus estimated to provide approximately $64,400 in annual net economic benefits, and has a benefit-cost ratio of 2.67 (see Table 23 (Results of Recreation Analysis)). For simplicity's sake this does not include an assumption of increased attendance in the future, which, all else equal, would increase the BCR of the recreation measure. However, there is good reason to believe that annual attendance will actually increase over time as the result of population growth, improved accessibility, and improved aesthetics at the site as the restoration of the ponds is implemented. According to this analysis, the implementation of the bridge is economically justified.

Table 23: Results of Recreation Analysis

Annual Cost	$38,500
Annual Benefits	$102,900
Annual Net Benefits	$64,400
Benefit-Cost Ratio	2.67

7. Regional Economic Development & Other Social Effects

The following two sections describe the Regional Economic Development and the Other Social Effects accounts as they pertain to the without- and/or with-project condition.

7.1. Regional Economic Development (RED)

According to EC 1105-2-409, "the regional economic development account registers changes in the distribution of regional economic activity that result from each alternative plan". In general, the RED account shows the effects of different plan alternatives on the distribution of regional economic activity in the area where implementation of the plan will have significant impacts on income and employment. The RED impacts are not added to the NED account.

All of the projects are expected to have positive regional economic impacts as a result of both a reduction in flood risk and the expenditure of funds to implement the projects. The benefits from the reduction in flood risk are generally captured in the NED analysis, while this section aims to quantify the regional impact from the expenditure of construction funds.

Implementation of a project would result in significant construction expenditure and demand for both construction labor and construction support services, providing short-term regional economic benefits. In addition to construction labor demand and increased manufacturing labor demand (due to a greater need for construction materials), the private sector may benefit from the project through contracted construction management, architectural, and landscaping employment opportunities. Expenditure on construction materials, labor, and services would in turn have a "trickle down" effect throughout the region as increased employment opportunities and higher overall earnings generate spending and inter-industry economic activity.

The RECONS model is a USACE-approved web-based model for estimating the regional economic impact of the expenditure of funds for projects or studies. The model was run using the default spending profile (assumptions on how cost is distributed across different tasks) and local purchase coefficients (assumptions on what percentage of the spending stays in the local economy versus slipping out to the broader region and nation). The model used a generic metropolitan area in California as the region of impact; no specific location is available in the model for projects that are not already in construction.

Table 24 (RED Impacts – NED/NER and LPP with Pond A18 Restoration Only) and Table 25 (RED Impacts – NED/NER and LPP with Restoration of All Ponds) show the results from the RECONS model for the components of the NED/NER plan and the larger LPP. Results for both multipurpose plans involving just the restoration of Pond A18 and of all of the study area ponds are shown. The FRM results are equivalent between the two tables, but the ER options differ since one table is for Pond A18 only, while the other is for all of the study area ponds. The outputs are restricted to the greater metropolitan area, and the overall economic impact for the state and nation would be larger than what is shown below. Note that these results are based upon FY14 price levels. Costs for the NED/NER and LPP Plans have been updated to FY15 price levels (as presented in Sections 8). The RED analysis will be updated to reflect these updated costs for the Final Report.

The jobs estimated are simply annual equivalents, and are not necessarily new or permanent jobs. For example, assuming it takes three years to construct the NED FRM Option, it is estimated that about 430 jobs will be supported each of the three years – for a total of approximately 1,300. The extent to which these will be new jobs for persons currently unemployed or underemployed will depend on the labor market at the time of construction.

Table 24: RED Impacts – NED/NER and LPP with Pond A18 Restoration Only

Impacts		NED FRM Option	Locally-Preferred FRM Option	NER Option (A18)	LPP ER Option (A18)
Total Spending		$65,372,000	$77,763,000	$9,020,000	$32,838,000
Direct Impact					
	Output	$55,493,094	$65,958,088	$7,089,975	$25,123,088
	Job	916	1,089	78	275
	Labor Income	$40,899,324	$48,612,197	$3,169,064	$11,229,470
	GRP*	$45,971,834	$54,641,290	$3,546,234	$12,565,959
Total Impact (Direct & Indirect)					
	Output	$105,815,542	$125,770,440	$13,212,026	$46,816,367
	Job	1,295	1,540	123	435
	Labor Income	$58,012,744	$68,952,898	$5,341,236	$18,926,490
	GRP	$75,572,509	$89,824,118	$7,136,414	$25,287,640

Table 25: RED Impacts – NED/NER and LPP with Restoration of All Ponds

Impacts		NED FRM Option	Locally-Preferred FRM Option	NER Option (All Ponds)	LPP ER Option (All Ponds)
Total Spending		$65,372,000	$77,763,000	$27,002,000	$36,744,000
Direct Impact					
	Output	$55,493,094	$65,958,088	$21,254,970	$28,923,510
	Job	916	1,089	233	317
	Labor Income	$40,899,324	$48,612,197	$9,500,506	$12,928,175
	GRP*	$45,971,834	$54,641,290	$10,631,220	$14,466,838
Total Impact (Direct & Indirect)					
	Output	$105,815,542	$125,770,440	$39,608,207	$53,898,377
	Job	1,295	1,540	368	501
	Labor Income	$58,012,744	$68,952,898	$16,012,442	$21,789,540
	GRP	$75,572,509	$89,824,118	$21,394,186	$29,112,954

*Gross Regional Product (equal to gross revenues minus intermediate inputs)

7.2. Other Social Effects (OSE)

OSE is defined by EC 1105-2-409 for use in USACE feasibility studies: "The other social effects account registers plan effects from perspectives that are relevant to the planning process, but are not reflected in the other three accounts". Measurement of OSE is generally qualitative; however, quantitative data is encouraged within available and accepted methods. This section discusses the OSE account with respect to the FRM options.

An OSE handbook (2013-R-13) has recently been published by the Institute for Water Resources (IWR), which is part of the USACE. The publication is entitled "Applying Other Social Effects in Alternatives Analysis." Table 26 (OSE Social Factors (from IWR Report 2013-R-13)) below identifies and describes the social factors that the USACE recommends for consideration when evaluating the social effects of alternatives.

Table 26: OSE Social Factors (from IWR Report 2013-R-13)

Social Factor	Description
1. Health and Safety	Perceptions of personal and group safety and freedom from risks
2. Economic Vitality	Personal and group definitions of quality of life, which is influenced by the local economy's ability to provide a good standard of living
3. Social Connectedness	Community's social networks within which individuals interact; these networks provide significant meaning and structure to life
4. Identity	Community members' sense of self as a member of a group, in that they have a sense of definition and grounding
5. Social Vulnerability and Resiliency	Probability of a community being damaged or negatively affected by hazards and its ability to recover from a traumatic event
6. Participation	Ability of community members to interact with others to influence social outcomes
7. Leisure and Recreation	Amount of personal leisure time available and whether community members are able to spend it in preferred recreational pursuits

As described briefly below, under the future without-project condition the impacts on the social factors shown in Table 26 would be very significantly adverse, while the structural options (levee construction) would to an almost equivalent degree significantly reduce the adverse social effects that would otherwise be expected in the absence of a project.

7.2.1. Without-Project Condition (No Action Alternative)

Under the without-project condition, the increasing future flood risk represents a real risk to human health and safety in the study area. Also, in the aftermath of a flood event, the temporary or long-term displacement of people and businesses would adversely alter the community and the lives of those affected. If the flooding were severe enough to damage an unprotected WPCP, the potential release of raw sewage into the bay and the loss of service would have catastrophic impacts on the region. In the long-term, the increasing flood risk would be expected to force people to relocate out of the floodplain, and the community of Alviso would either be significantly adversely impacted or cease to exist altogether. The relocation of structures out of the area would be expected to include an elementary school, several churches, and potentially the San Jose Fire Department Station #25. The without-project condition would be associated with very significant adverse consequences across all of the factors listed in Table 26 (OSE Social Factors (from IWR Report 2013-R-13))– especially in the community of Alviso that would be affected most severely.

7.2.2. Non-Structural Option

The non-structural FRM option involves an evacuation of the high-risk area of the floodplain, and would relocate hundreds of homes, businesses, and public buildings – including all properties within the community of Alviso. While this option would be highly effective at reducing flood risk in the study area, it would very clearly have significant adverse social impacts. By dispersing the residents and businesses from the high risk flood zone, this option would eliminate the community of Alviso, disrupting lives, and adversely affecting hundreds of families and relationships in the community. The fire station would have to be relocated as well. This option would have significant adverse impacts across all seven of the social factors shown in Table 26 (OSE Social Factors (from IWR Report 2013-R-13)).

7.2.3. Structural Options

The structural project options are essentially identical in their expected social impacts. They would all prevent the adverse social impacts described under the without-project condition. They would all significantly reduce the flood risk in the study area, and thus would improve human health and safety. There would be no displacement of residents or businesses as there would be under the non-structural option and would be expected under the without-project future condition. The decrease in flood risk compared to the without-project condition would be expected to increase the value of land and the properties in the floodplain, although the magnitude of this increase is highly uncertain and thus has not been quantified in this report. Overall each of the structural options would have a strongly positive impact on the community and public health and safety.

8. Results for the Tentative NED/NER and Locally Preferred Plans

8.1. Flood Risk Management (Comparison of NED Plan and LPP)

The evaluation of the final array of alternatives identified the single-purpose NED FRM option, which is the option with the greatest net national economic benefits. As described previously, depending on the SLC scenario one of two levee heights would be identified as the NED option. The costs and benefits of the two levee heights (12.5’ and 13.5’) are very similar. The 13.5’ levee has been tentatively selected to be the NED FRM option based on lower residual risk under all three scenarios. In particular, the larger levee had significantly less residual risk towards and at the end of the period of analysis under the USACE High SLC scenario. As shown in Section 4, whereas at 2067 under the USACE High SLC scenario the 12.5’ levee has a 9% annual chance of being overtopped by coastal water, the 13.5’ levee has less than a 1% chance of being overtopped. However, Corps planning guidance also generally recommends selection of smaller scale plans when plans have similar net benefits[20]. Since the 12.5’ levee has similar net benefits to the 13.5’ levee across all three SLC scenarios, and because it could potentially be raised in the future if necessary due to higher sea level rise than that projected under the low or intermediate scenarios, it is possible that the 12.5’ levee may be ultimately selected as the NED FRM option. This decision will be made prior to completion of the Final Report submittal.

The locally preferred FRM option is a 15.2’ levee along the same alignment as the Tentative NED option. The results for these two options are displayed in Table 27 (Comparison of Tentative NED and LPP FRM Options ($1,000s)) below. The results have been updated to FY 15 price levels. In accordance with USACE policy, the results are shown at both the FY2015 discount rate of 3.375% and at the higher rate of 7%. The higher rate reflects a higher opportunity cost of capital. As Table 27 shows, the results for the two options are very similar. The small expected residual damage associated with the Tentative NED levee under the USACE High SLC scenario is effectively eliminated with the larger LPP levee. This decrease in with-project damage is not enough to offset the increase in project cost, which is why the net benefits of the LPP levee are slightly lower than the Tentative NED levee for each SLC scenario.

[20] ER 1105-2-100, Appendix G, Exhibit G-1.

Table 27: Comparison of Tentative NED and LPP FRM Options ($1,000s) – FY 15 Price Levels & Discount Rate

	NED FRM			LPP FRM		
	13.5' Levee			15.2' Levee		
SLC Scenario	Low	Intermediate	High	Low	Intermediate	High
Without-Project						
Equivalent Annual Flood Damage	$18,932	$23,573	$42,137	$18,932	$23,573	$42,137
With-Project						
Equivalent Annual Flood Damage	$3	$3	$99	$0	$0	$0
Equivalent Annual Damage Reduced	$18,929	$23,570	$42,038	$18,932	$23,573	$42,137
Project Costs						
Project First Cost	$70,987			$85,797		
Interest During Construction	$3,552			$4,292		
Total Investment Cost	**$74,538**			**$90,089**		
Average Annual Cost	$3,107			$3,755		
Annual O&M Cost	$539			$539		
Total Average Annual Cost	**$3,646**			**$4,294**		
Results @ 3.375%						
Annual Net Benefits	**$15,283**	**$19,924**	**$38,392**	**$14,638**	**$19,279**	**$37,843**
Benefit-to-Cost Ratio	**5.19**	**6.47**	**11.53**	**4.41**	**5.49**	**9.81**
Costs and Benefits @7%						
Equivalent Annual Damage Reduced	**$20,030**	**$23,044**	**$37,848**	**$20,030**	**$23,044**	**$37,886**
Total Average Annual Cost	**$6,225**			**$7,411**		
Annual Net Benefits	**$13,806**	**$16,819**	**$31,623**	**$12,619**	**$15,632**	**$30,474**
Benefit-to-Cost Ratio	**3.22**	**3.70**	**6.08**	**2.70**	**3.11**	**5.11**

Table 28 (Project Performance Statistics at 2067 – 13.5’ and 15.2’ Levees) displays the project performance statistics from the HEC-FDA modeling for the 13.5’ and 15.2’ levees at the end of the period of analysis. The results indicate that there is a very low risk of coastal flood damage with either of the levee heights. In general the performance of the levees is very similar, and the only significant difference between the two emerges under the USACE High SLC scenario. For example, while there is a very high likelihood of either levee heights containing up to the 0.2% ACE coastal storm water elevation under the USACE Low and Intermediate SLC scenarios, under the USACE High SLC scenario the likelihood of containing the event is just 33% for the 13.5’ levee but 99.9% for the 15.2’ levee.

Table 28: Project Performance Statistics at 2067 – 13.5’ (Tentative NED) and 15.2’ (LPP) Levees

SLC Scenario	FRM Option	Mean Annual Exceedence Probability in 2067	Long-Term Risk (30 Years)	Conditional Non-Exceedence Probability by Event			
				10%	2%	1%	0.20%
Low	13.5' Levee	0.02%	0.7%	99.9%	99.9%	99.9%	99.9%
	15.2' Levee	0.01%	0.4%	99.9%	99.9%	99.9%	99.9%
Intermediate	13.5' Levee	0.02%	0.6%	99.9%	99.9%	99.9%	99.9%
	15.2' Levee	0.01%	0.3%	99.9%	99.9%	99.9%	99.9%
High	13.5' Levee	0.48%	13.4%	99.9%	98.3%	88.2%	33.5%
	15.2' Levee	0.02%	0.6%	99.9%	99.9%	99.9%	99.9%

Table 29 compares some of the important overall FRM outputs of the two levee heights, including the net benefits, BCR, and residual damage in both equivalent annual terms and at the end of the period of analysis (2067).

Table 29: Summary of Results for 13.5’ (Tentative NED) and 15.2’ (LPP) Levees ($1,000s)

SLC Scenario	FRM Option	Total Equivalent Annual Benefits	Net Benefits	BCR @ 3.5%	Residual Equivalent Annual Damage	Residual Annual Damage in 2067	Average Annual Exceedence Probability in 2067
Low	13.5' Levee	$18,929	$15,283	5.19	$3	$60	0.02%
	15.2' Levee	$18,932	$14,683	4.41	$0	$0	0.01%
Intermediate	13.5' Levee	$23,570	$19,924	6.47	$3	$60	0.02%
	15.2' Levee	$23,573	$19,279	5.49	$0	$0	0.01%
High	13.5' Levee	$42,038	$38,392	11.53	$99	$1,500	0.48%
	15.2' Levee	$42,137	$37,843	9.81	$0	$0	0.02%

8.2. National Ecosystem Restoration (Comparison of NER Plan and LPP)

As described in Section 5, the NER Plan includes basic restoration of all of the ponds considered in the study. The NER Plan is the largest of the four “Best Buy” restoration plans. There is a locally preferred plan (LPP) that is larger in scale than the Tentative NED/NER Plan with respect to both the FRM and ER options. As noted in Section 8.1, the LPP has the same FRM alignment as the Tentative NED Plan, but will be designed to a final height of 15.2’ instead of 13.5’. The NER component of the LPP includes 30:1 ecotone improvements in addition to basic pond restoration included in the NER Plan.

The final results, however, are reported on plans that do not include restoration work on lands owned by the U.S. Fish and Wildlife Service (USFWS), which includes Ponds A9 through A15. Only Pond A18 in the project area is not owned by the USFWS. According to current policy, the USACE does not have the ability to implement a restoration project on the USFWS land; however, pending implementation guidance for Section 1025 of WRRDA 2014 may allow the USACE implement these features on USFWS lands. Figure 28 and Figure 29 depict the Tentative NED/NER Plan and LPP. Total first costs for the ER plans presented in Section 5 have been updated to FY15 price levels. Updated costs for the NER and LPP ER plans are currently estimated as follows:

- NER Plan (All Ponds) - $34.84 million
- NER Plan (A18 Only) - $8.89 million
- LPP ER Plan (All Ponds) - $72.96 million
- LPP ER Plan (A18 Only) - $36.21 million.

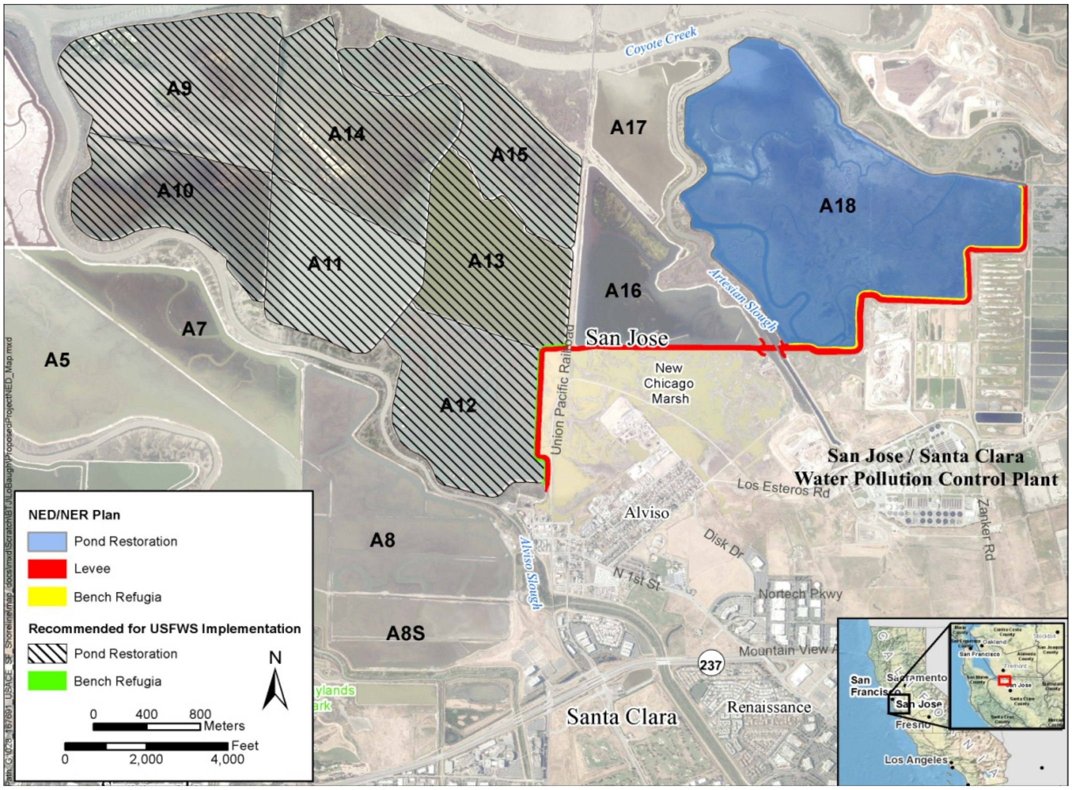

Figure 28: Conceptual Design of Tentative NED/NER Plan

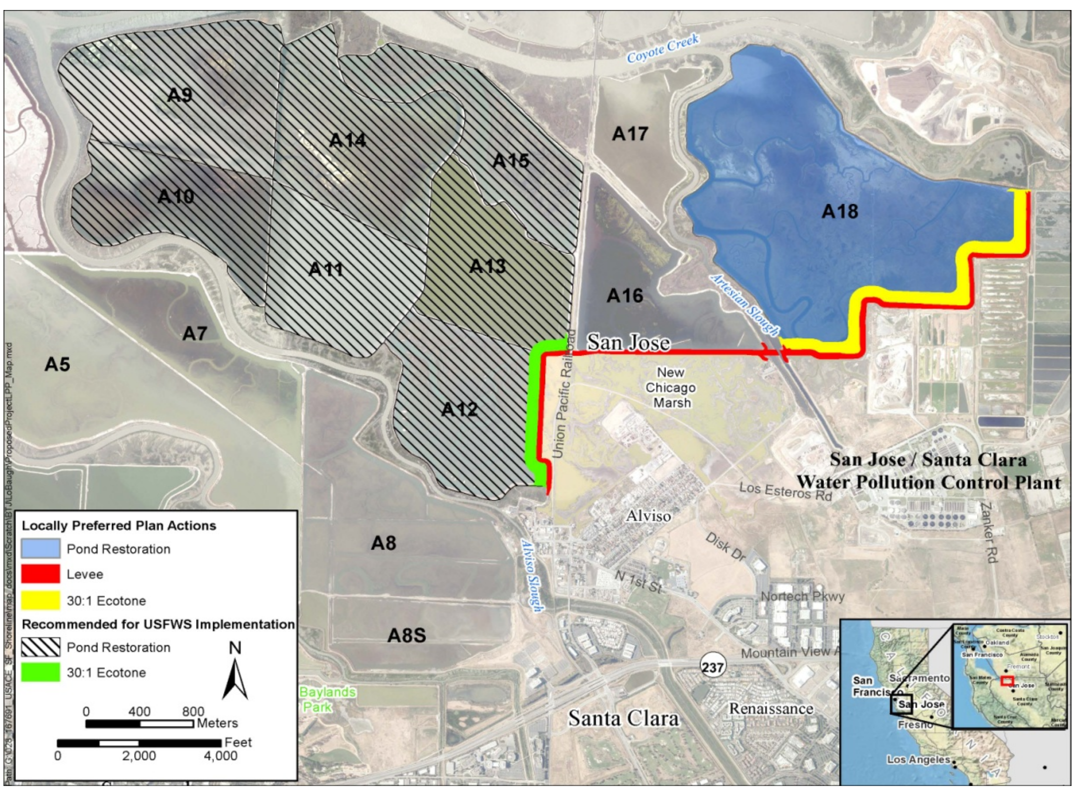

Figure 29: Conceptual Design of LPP

8.3. Summary of Benefits & Costs for Tentative NED/NER Plan and LPP

The following presents summarizes benefits and costs for the Tentative NED/NER Plan, as well as the LPP.

8.3.1. Cost Allocation

For multipurpose projects, costs must be allocated between project purposes (in this case, flood risk management (NED) and ecosystem restoration (NER). For both the Tentative NED/NER Plan and the LPP Combined Plan, all of the levee construction costs have been allocated to the FRM purpose, and all of the pond restoration costs have been allocated to the ER purpose.

For a single purpose FRM project, there would be some environmental impacts. However, the costs for mitigating for such impacts would be insignificant relative to the overall costs. Further, since the ER component of the multipurpose project provides a significant net gain in ecological outputs, a combined plan would not require mitigation and a determination was made that it is not necessary to allocate any ecosystem restoration related costs to the FRM component of the project.

If the ER components of the Tentative NED/NER or LPP Plans were implemented without the FRM levee components of these plans, the ER components would require flood risk mitigation, as these features would result in induced flood risk. The cost of such mitigation would be very significant. Accordingly, ER plans were formulated and evaluated incrementally as a second-added purpose, once the optimal levee alignments and the Tentative NED and LPP FRM plans were identified. In essence, the FRM features will allow for restoration to take place in the pond complexes – such restoration would not be considered as a stand-alone feature without first implementing the FRM component. Therefore, it has also been determined that no flood risk mitigation related costs should be allocated to the ER components of the Tentative NED/NER or LPP Plans. The costs in the summary table in the following section reflect these results and conclusions.

8.3.2. Summary of Results

Table 30 which follows summarizes the benefits and costs for the Tentative NED/NER Plan and the LPP Combined Plan. The Tentative NED levee height is 13.5'. As noted earlier in this appendix, it is possible that the NED levee height may ultimately be determined to be 12.5', since a 12.5' levee was the NED scale under the low and intermediate SLC scenarios, and because there is only a minor difference in net benefits between the 12.5' and 13.5 feet levee scales under all three SLC scenarios evaluated. As shown in the table, the FRM features for both the Tentative NED/NER Plan as well as the LPP are well economically justified under all three SLC scenarios.

Table 30 also presents summary results for the ER component of the Tentative NED/NER Plan and LPP Combined Plan. Separate results are presented for the NER Plan features that include restoration of all pond complexes, as well as for just Pond A18 (which is the only pond currently eligible to be included as part of a cost shared project with USACE). These results show that the average annual cost per AAHU for the NER Plan and just the Pond A18 component of the NER Plan are similar. All of the pond complexes (with basic restoration) were identified as efficient Best Buy plan components of the NER Plan.

The LPP ER plan includes an ecotone, which was formulated to provide a more complete and sustainable restoration plan. However, the currently available and certified habitat model used to evaluate ecosystem benefits for this study does not provide the degree of sophistication needed to demonstrate this. Because the output results for the ER component of the LPP reflect a substantial increase in costs but do not reflect an increase in ER benefits, the average annual cost per AAHU is significantly higher for the LPP than for the Combined NED/NER Plan.

Table 30: Summary of Results

	NED/NER Plan			Locally-Preferred Plan		
NED ACCOUNT						
Investment Costs						
FRM First Costs	$70,986,950			$85,796,997		
Interest During Construction	$3,551,513			$4,292,468		
Total	**$74,538,463**			**$90,089,465**		
Annual Cost						
Interest and Amortization	$3,106,559			$3,754,682		
Annual Maintenance Cost	$539,000			$539,000		
Total Annual Cost	**$3,645,559**			**$4,293,682**		
USACE SLC Scenario	**Low**	**Intermediate**	**High**	**Low**	**Intermediate**	**High**
Annual Benefits	$18,928,550	$23,569,975	$42,037,551	$18,931,616	$23,573,041	$42,136,696
Net Annual FRM Benefits	$15,282,991	$19,924,416	$38,391,992	$14,637,934	$19,279,359	$37,843,014
Benefit to Cost Ratio	5.19	6.47	11.53	4.41	5.49	9.81
EQ ACCOUNT (NER PLAN - ALL PONDS)						
Investment Costs						
ER First Costs	$34,836,214			$72,957,193		
Interest During Construction	$1,742,874			$3,650,086		
Total	**$36,579,087**			**$76,607,279**		
Average Annual Cost	$1,524,516			$3,192,781		
Average Annual Habitat Units	48,508			48,308		
Cost per Habitat Unit	$31			$66		
EQ ACCOUNT (NER PLAN - POND A18 ONLY)						
Investment Costs						
ER First Costs	$8,886,372			$36,212,771		
Interest During Construction	$444,590			$1,811,743		
Total	**$9,330,961**			**$38,024,514**		
Average Annual Cost	$388,889			$1,584,758		
Average Annual Habitat Units	14,577			14,437		
Cost per Habitat Unit	$27			$110		

ADDENDUM A – Without Project Exceedance Probability/Damage Functions

The following table and figures present without project exceedance probability/damage functions under low, intermediate and high sea level scenarios. Note that the damages presented below reflect adjustments to the structure inventory each decade to account for structure relocations. Also, these damages are based upon water surface elevations resulting from/assuming levee failure. The HEC-FDA model applies the damage functions only in simulations resulting in levee failures during the Monte Carlo simulation process.

Table 31: Without Project Exceedance Probability Damage Functions

South San Francisco Shoreline Without Project Conditions Exceedance Probability/Damage Functions ($1,000s) Low Sea Level Rise Scenario						
ACE	**2017**	**2027**	**2037**	**2047**	**2057**	**2067**
10.0%	$ 89,177	$ 75,663	$ 76,824	$ 73,050	$ 74,428	$ 77,801
4.0%	$ 106,073	$ 91,954	$ 93,008	$ 88,643	$ 89,590	$ 93,009
2.0%	$ 115,109	$ 102,422	$ 103,865	$ 100,474	$ 102,918	$ 107,474
1.0%	$ 128,995	$ 115,303	$ 117,356	$ 114,572	$ 117,501	$ 122,510
0.2%	$ 160,635	$ 147,319	$ 149,376	$ 146,059	$ 148,265	$ 166,818
EAD	$ 11,356	$ 8,500	$ 10,280	$ 10,109	$ 11,134	$ 13,454

South San Francisco Shoreline Without Project Conditions Exceedance Probability/Damage Functions ($1,000s) Intermediate Sea Level Rise Scenario						
ACE	**2017**	**2027**	**2037**	**2047**	**2057**	**2067**
10.0%	$ 89,177	$ 80,556	$ 80,881	$ 83,978	$ 64,283	$ 75,291
4.0%	$ 106,073	$ 97,197	$ 94,996	$ 101,780	$ 84,076	$ 97,366
2.0%	$ 115,109	$ 106,964	$ 106,961	$ 117,187	$ 98,687	$ 111,207
1.0%	$ 128,995	$ 119,972	$ 128,278	$ 132,299	$ 111,810	$ 123,353
0.2%	$ 160,635	$ 155,323	$ 155,605	$ 160,105	$ 134,996	$ 144,557
EAD	$ 11,356	$ 10,075	$ 12,654	$ 15,000	$ 17,052	$ 28,223

South San Francisco Shoreline Without Project Conditions Exceedance Probability/Damage Functions ($1,000s) High Sea Level Rise Scenario						
ACE	**2017**	**2027**	**2037**	**2047**	**2057**	**2067**
10.0%	$ 89,177	$ 97,626	$ 104,058	$ 97,487	$ 57,220	$ 75,973
4.0%	$ 106,073	$ 115,963	$ 127,657	$ 115,715	$ 66,860	$ 88,617
2.0%	$ 115,109	$ 132,258	$ 143,181	$ 125,528	$ 75,221	$ 101,799
1.0%	$ 128,995	$ 147,319	$ 155,312	$ 135,127	$ 82,555	$ 115,534
0.2%	$ 160,635	$ 173,880	$ 176,623	$ 158,304	$ 106,864	$ 152,069
EAD	$ 11,356	$ 19,884	$ 32,221	$ 37,212	$ 25,829	$ 41,943

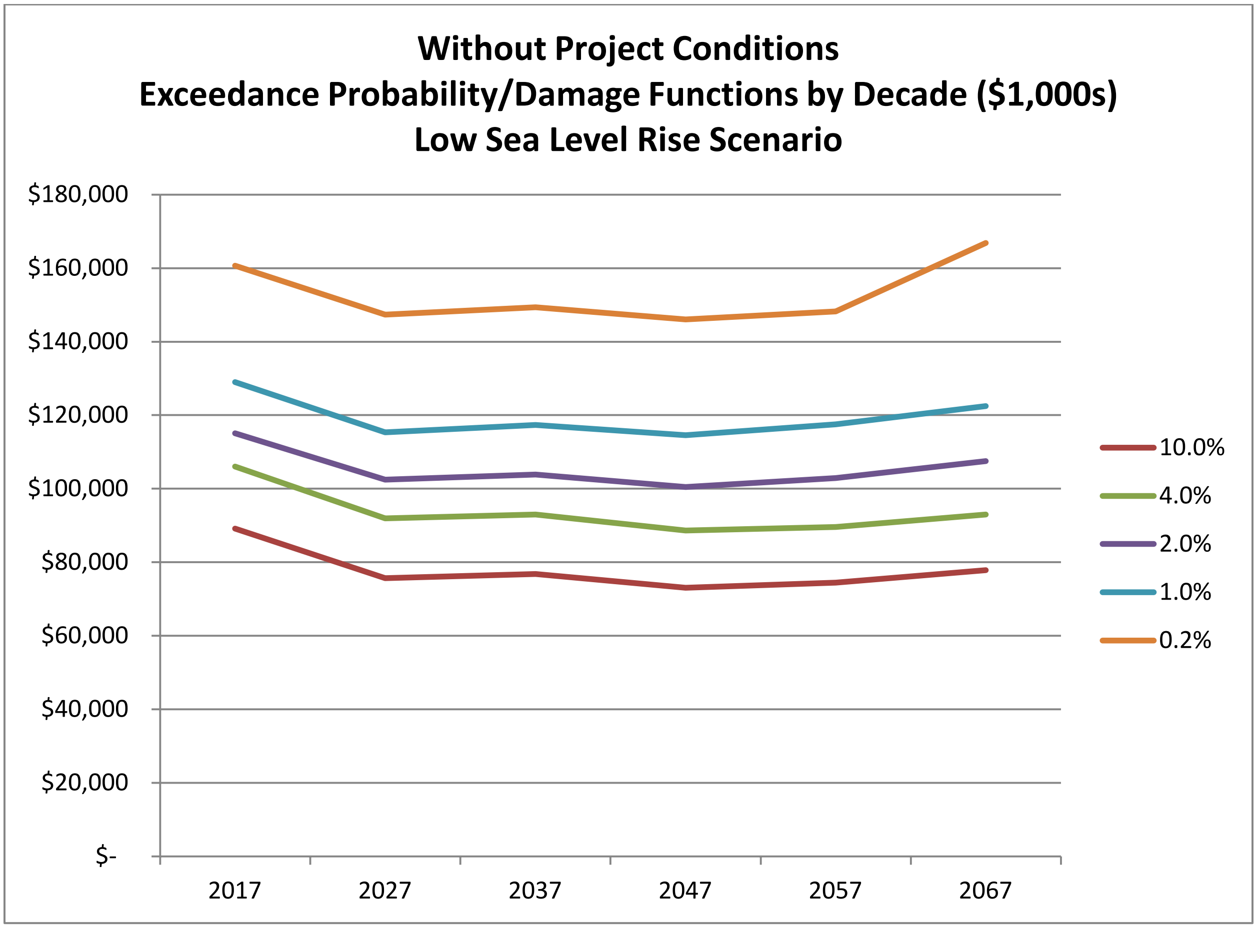

Figure 30: Without Project Exceedance Probability Damage Functions, Low SLR Scenario

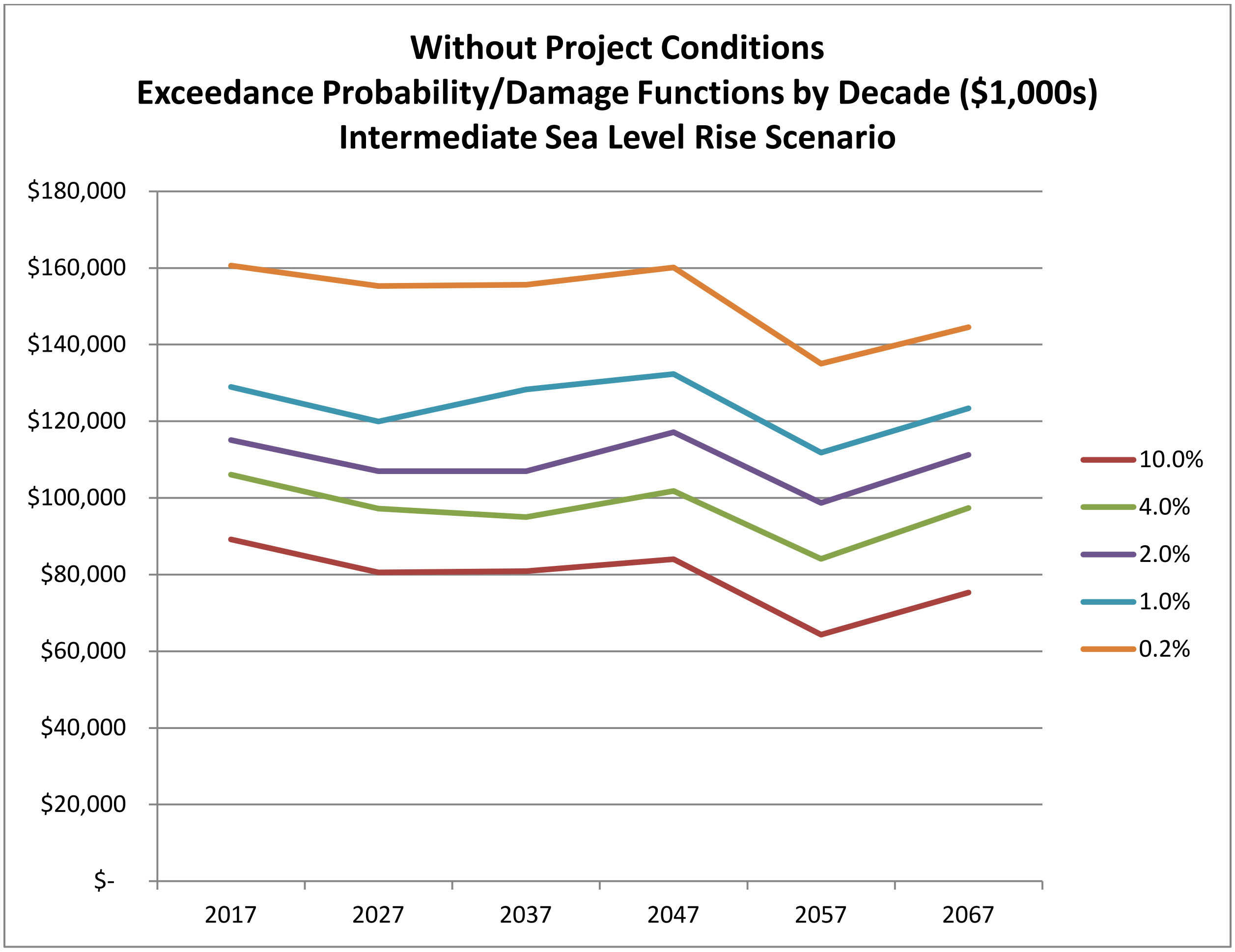

Figure 31: Without Project Exceedance Probability Damage Functions, Intermediate SLR Scenario

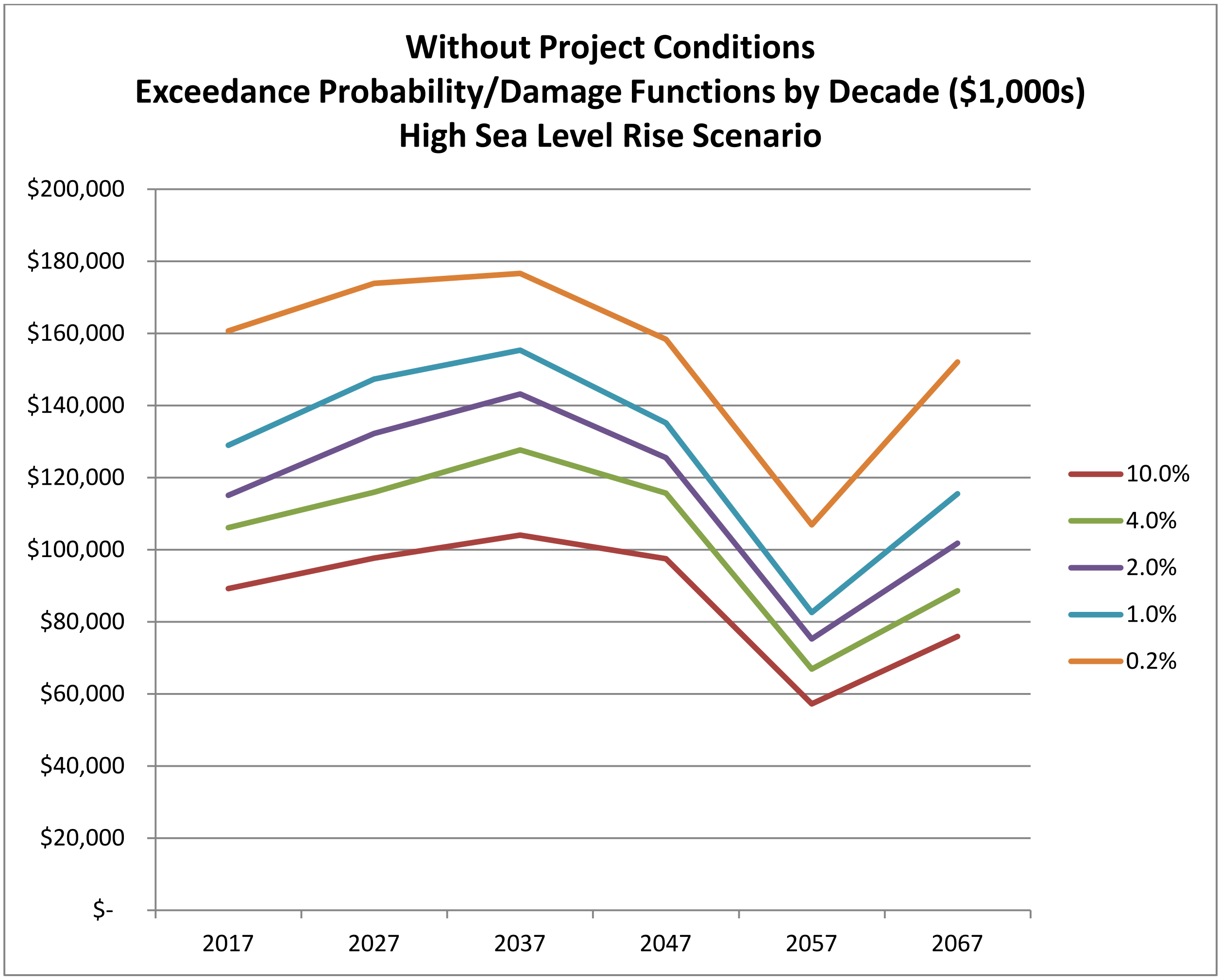

Figure 32: Without Project Exceedance Probability Damage Functions, High SLR Scenario

ADDENDUM B – Sensitivity Analysis: Economic Justification & Levee Failure Probability

As shown in this Economic Appendix, there is a very strong economic justification for the construction of a levee to reduce the risk of flooding in the study area. The strong justification is in large part the result of the finding that there is currently a high annual likelihood of flooding in the study area. The most uncertain of the inputs to the estimation of the likelihood of flooding in the study area is the likelihood of failure of the outer dike, which is incorporated in the FDA model as the without-project levee failure function. Because of the uncertainty, an obvious and useful sensitivity analysis is to determine how changes to the levee failure function affect project economic justification. The following presents the results of this sensitivity analysis.

Summary of Existing Dike-Pond System Performance

The FDA program produces what it calls "performance statistics" that are an indicator of the likelihood of damaging flood events under both the without- and with-project conditions. When levees (or dikes) are present that have some likelihood of geotechnical failure (as is the case under the without-project condition), the project performance is computed based on the joint probability of annual exceedance and probability of geotechnical failure – breach or overtopping of the levee is thus the Target Stage referenced in the development of the performance statistics. Table 32 below shows the performance results for the existing dike-pond system in the year 2017, which is the project's base year. The Annual Exceedance Probability is the likelihood that a damaging flood event will occur in any given year, the Long-Term Risk is the risk of damaging event over some defined period of time for a particular water surface profile, and the Conditional Non-Exceedance Probability is the likelihood that the damages would not occur as the result of a particular exceedance probability event. According to the FDA model, beginning in 2017 there is about a 32% chance of a damaging flood event in any given year. Figure 33 shows how likely it is to have one or more damaging flood events over different periods of time.

Table 32: Performance Statistics for Existing Dike-Pond System at 2017

Stream Name	Target Stage	Target Stage Annual Exceedance Probability		Long-Term Risk (years)			Conditional Non-Exceedance Probability by Events					
		Median	Expected	10	30	50	10%	4%	2%	1%	.4%	.2%
SSFS - Alviso	levee	0.3203	0.3211	0.9792	1.0000	1.0000	0.5272	0.3810	0.3528	0.2954	0.1950	0.1331

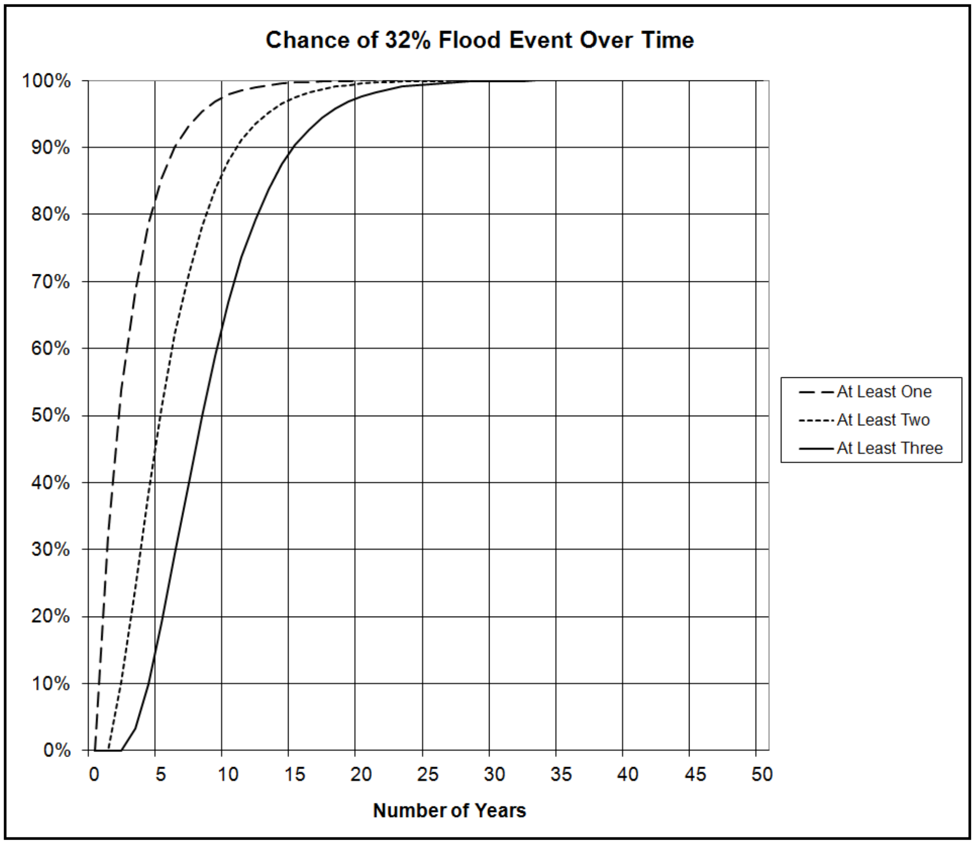

Figure 33: Binomial Distribution of Multiple Flood Events over Time Beginning 2017

The without-project performance of the dike-pond system changes over time with sea-level rise, and the performance varies by scenario. Table 33 below shows the performance statistics at the end of the period of analysis (2066) under the intermediate SLR scenario. Under any of the future scenarios considered the risk increases in the future. Table 33 shows that, according to the flood damage analysis, by 2066 the annual likelihood of a damaging flood event is essentially a coin flip, and over a ten-year period the chance of a damaging flood event is a virtual certainty.

Table 33: Performance Statistics for Existing Dike-Pond System at 2066 (Intermediate SLR Scenario)

Stream Name	Target Stage	Target Stage Annual Exceedance Probability		Long-Term Risk (years)			Conditional Non-Exceedance Probability by Events					
		Median	Expected	10	30	50	10%	4%	2%	1%	.4%	.2%
SSFS - Alviso	levee	0.5339	0.5325	0.9995	1.0000	1.0000	0.2960	0.1283	0.0734	0.0541	0.0363	0.0246

Modifications to Levee Failure Curve

The uncertainty in the levee failure function is greater at the lower elevations, and so for this sensitivity analysis an adjustment was made to the probability of failure near the bottom of the levee – between 7' and 10'. The probability of failure was set to zero between above 7' and below 10'. At and above 10' the probability of failure was unchanged from the expected value curve as described previously. Altering the failure curve at the lower elevation to this degree is simply an adjustment that was made for purposes of understanding the sensitivity of the economic justification to the changes in the failure curve; the adjusted curve is not an alternative to what the USACE engineers consider is the most likely relationship between water elevation and probability of levee failure. The two curves are shown in Figure 34 below for comparison's sake.

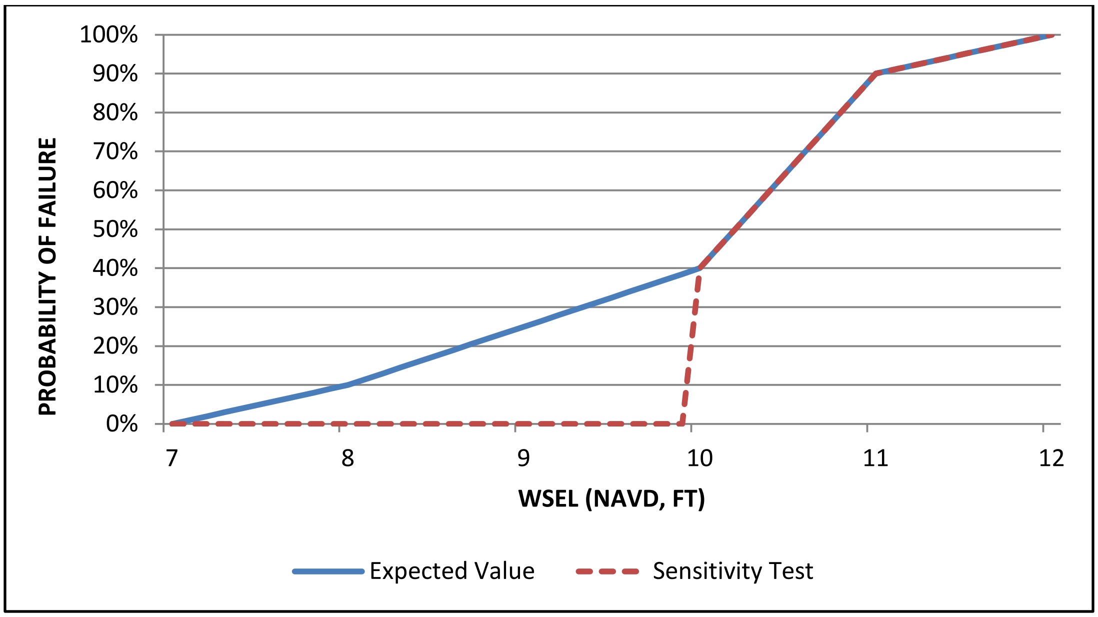

Figure 34: Levee Failure Function Comparison – Economic Justification Sensitivity Test

Sensitivity Analysis Results

For the sensitivity analysis, the without-project FDA models for the low sea-level rise scenario were altered to include the adjusted levee failure function. As a result of the significant decrease in the risk of flooding, the sensitivity analysis assumed no relocations would occur. The tables below show the results of this sensitivity analysis.

As Table 34 below shows, the change to the failure function reduces the annual likelihood of damage from 32% (see Table 32) at 2017 to 7%. However an AEP of 7% is still significant and would almost certainly lead to failure over the fifty-year period of analysis.

Table 34: Without-Project Performance with Adjusted Failure Function

Target Stage	Target Stage Annual Exceedance Probability		Long-Term Risk (years)			Conditional Non-Exceedance Probability by Events					
	Median	Expected	10	30	50	10%	4%	2%	1%	.4%	.2%
levee	0.0689	0.0727	0.5298	0.8960	0.9770	0.6618	0.3999	0.3567	0.2929	0.1939	0.1311

Table 35: Sensitivity Test Results - Economic Justification

Without-Project Equivalent Annual Flood Damage (1,000s)											
Structure & Content Damage	$8,688										
Relocation Cost	$756										
Total	$9,443										
With-Project Equivalent Annual Damages & Damages Reduced (1,000s)											
	No Action	**10.5' Levee**	**11' Levee**	**11.5' Levee**	**12' Levee**	**12.5' Levee**	**13' Levee**	**13.5' Levee**	**14' Levee**	**15' Levee**	**Non-Structural**
With-Project Avg Annual Flood Damage	$9,443	$6,244	$2,418	$1,123	$84	$17	$6	$3	$1	$0	$0
Annual Damages Reduced	$0	$3,199	$7,026	$8,320	$9,359	$9,427	$9,438	$9,441	$9,442	$9,443	$9,443
Project Costs (1,000s)											
Project Cost	$0	$56,611	$58,186	$59,761	$61,336	$62,486	$63,636	$65,536	$67,436	$71,536	$425,000
IDC	$0	$2,939	$3,021	$3,102	$3,184	$3,244	$3,304	$3,402	$3,501	$3,714	$0
Total Investment Costs	$0	$59,550	$61,207	$62,863	$64,520	$65,730	$66,940	$68,938	$70,937	$75,250	$425,000
Capital Recovery Factor (CRF)	0.0426	0.0426	0.0426	0.0426	0.0426	0.0426	0.0426	0.0426	0.0426	0.0426	0.0426
Average Annual Costs	$0	$2,537	$2,607	$2,678	$2,749	$2,800	$2,852	$2,937	$3,022	$3,206	$18,105
Annual O&M Costs	$0	$387	$387	$387	$387	$387	$387	$387	$387	$387	$0
Total Average Annual Costs	$0	$2,924	$2,994	$3,065	$3,136	$3,187	$3,239	$3,324	$3,409	$3,593	$18,105
Results											
Annual Net Benefits	**$0**	**$275**	**$4,031**	**$5,255**	**$6,224**	**$6,240**	**$6,199**	**$6,117**	**$6,033**	**$5,851**	**-$8,662**
Benefit-to-Cost Ratio	**N/A**	**1.09**	**2.35**	**2.71**	**2.98**	**2.96**	**2.91**	**2.84**	**2.77**	**2.63**	**0.52**

As Table 35 above shows, the without-project damages decreased by nearly 50% compared to the damages under the low SLR scenario when using the expected probabilities for outer dike failure. However, as the results table shows, even under the low SLR scenario the levee project is still strongly justified with the adjusted failure function. Including some consideration of structure relocations would not materially change the results because of the offsetting effects of repeated flood damages or high relocation cost. These results reflect a lower bound as far as economic justification with a modification to the levee failure function, since they are based upon the low SLR scenario. Since without project damages and with project benefits are higher under the intermediate and high SLR scenarios, conducting this same sensitivity analysis on those scenarios would yield higher net benefits and benefit/cost ratios than those shown in the table above.